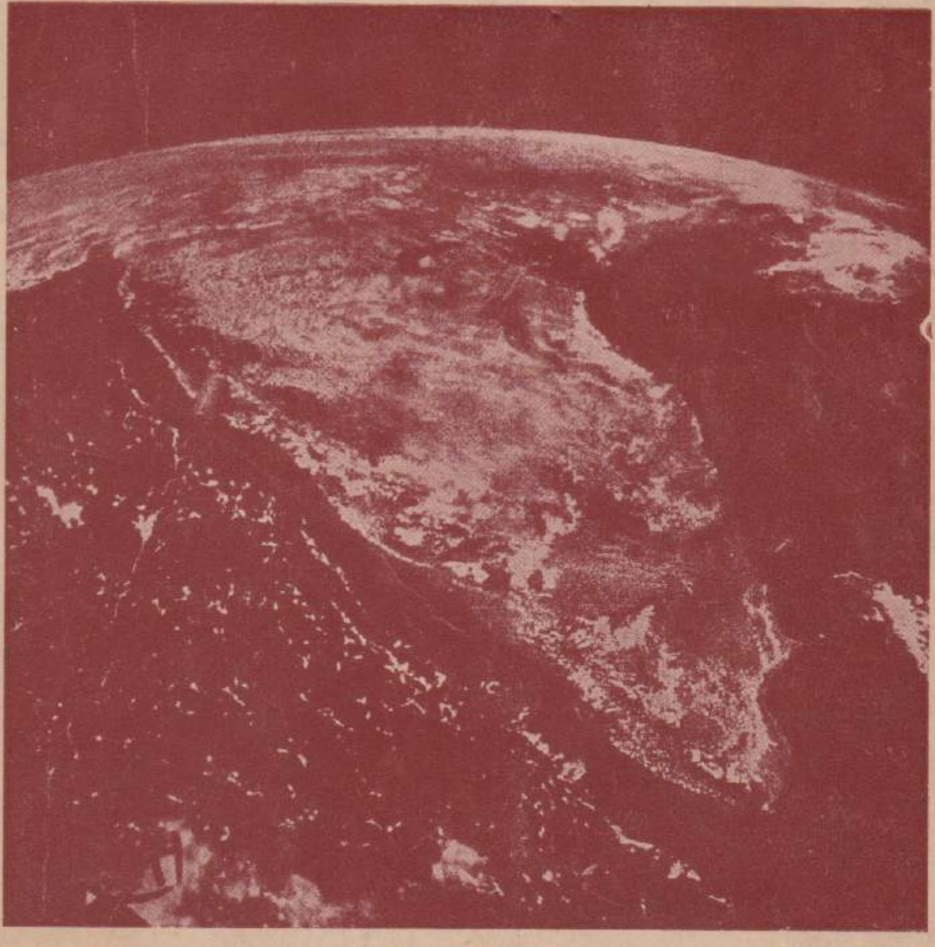
SOMETHING ABOUT GEOGRAPHY



Jack Gibson

© Jack Gibson 1973, 1975

First edition 1973
Second edition revised and enlarged 1975

Dedicated
to the memory of
Hendrik Willem Van Loon
who wrote *The Home of Mankind*,
a book that greatly stimulated my interest in
Geography.

The Cover

The Indian Peninsula as seen from an altitude of 700 km by the astronauts on *Gemini XI* spacecraft. The nose and antennae of *Gemini XI* are seen on the left foreground.

(Photograph by courtesy of National Aeronautics and Space Administration, U.S.A.)

This book has been published on paper supplied
by the Government of India
at a concessional rate.

Rs. 8.50

PRINTED AT INDRAPRASTHA PRESS (CBT), 4 BAHADURSHAH ZAFAR MARG, NEW DELHI 110001
AND PUBLISHED BY MUKUL PRAKASHAN, J-2, KAILASH COLONY, NEW DELHI-110048

FOREWORD

Something about Geography has been written by Mr Jack Gibson, former Principal of Mayo College, Ajmer, and he is one who needs no introduction to persons connected with education in India.

Mr Gibson has used his long classroom experience and knowledge of students to produce a simple, direct yet fundamentally sound introduction to the basic principles of Geography.

I would like to emphasize that chapters incorporating programmed learning techniques have distinct learning value.

The core and the basis of Geography-learning is explained in this book and it should be a valuable textbook for candidates on the threshold of making a deeper study of the subject.

A.E.T. Barrow
B.A., H. Dip. Ed. (Dublin), T.D.
Secretary
Council for the Indian School Certificate Examination
and
Honorary Secretary
Inter-State Board for Anglo-Indian Education

New Delhi
5 February 1973

AUTHOR'S NOTE

Geography should begin at home. When I started to teach it I began with the country round the school: its build or relief, its climate, how people lived, and their crops, manufactures and businesses. My class complained to the headmaster that I did not know my business for their district was not in the syllabus. There were, however, two words in the syllabus that they had overlooked: "Local Geography".

If a subject is to have reality for those to whom it is taught, it must be related to their personal experiences, of which more throughout this little book and especially in chapter 18. It is not possible, in a book like this, to base all Geography on any one particular area. The reader has to connect general principles with particular examples for himself. I have tried to cover the general basic principles of physical geography so that some, if not all, can and should be related to any locality, and I have set exercises to encourage the reader to do this.

Every student should own, or at the very least have access to, an atlas and a dictionary, and I have tried to encourage those who read this book to use these and other books of reference to find out things for themselves. For instance, it would have been easy to describe land forms such as a plateau or an isthmus, but I have suggested that these should be looked up in a dictionary, and I would suggest that *A Dictionary of Geography* (Penguin) should be made available to all students.

This is not a textbook to cover any particular examination syllabus, but I hope it contains enough information on physical geography to introduce the pupil to any good syllabus. It will remain for those who use it to apply this information to their locality, and to the world in general, and to think out how what I have written about affects peoples' lives, and to learn how they have met the challenges of nature and have developed their resources.

I have tried to draw attention to cause and effect, and to encourage understanding rather than learning by heart. The book is meant for students of about 12 to 14 years old, but older ones have told me that they have found it useful for revision, skipping parts that they already feel confident about.

It is aimed at explaining only general principles. The measurements used are approximate. A day is taken to be 24 hours of the earth's rotation. No account has been taken of the equation of time or the exact shape of the earth. These, and other attempts to get at the exact truth, are subjects that a student must usually wait to study till after he has left school.

Like all who learn I owe my little learning to others. I have used notes and diagrams collected over the years and have now forgotten from where some were copied, so cannot acknowledge my debt as I would like to. In teaching I have used books by Professor Dudley Stamp to whom so many geographers are so deeply indebted, and that excellent textbook *The Foundations of Geography* by Miss Preece and Mr Wood. While writing I consulted the following books:

A Dictionary of Geography by W.G. Moore—a Penguin reference book that anyone interested in geography should possess.

The Concise Oxford Dictionary

Roget's *Thesaurus of English Words and Phrases*, an invaluable book. Arnold Bennett described it as 'the most wonderful machine for getting at words you know but can't think of at the moment'.

The Admiralty Navigation Manual published by H.M. Stationery Office

Various atlases: *The Oxford, The Reader's Digest, Great World Atlas,* Goodall and Darby's *The University Atlas,* and the *School Atlas* printed by the Survey of India for the Ministry of Scientific Research and Cultural Affairs;

The Monsoons by Dr P.K. Das, published by the National Book Trust

Geology of India by Professor D.N. Wadia

India and Pakistan by Professor O.H.K. Spate

The cover, showing the Indian Peninsula as seen from an altitude of 700 km. by astronauts on *Gemini XI*, is by courtesy of National Aeronautics and Space Administration, U.S.A.

I am deeply grateful to Mr R.E. Hawkins, for some valuable suggestions, and Mr S.C. Dutta for reading the proofs.

J. G.

CONTENTS

		Page
1	What's in a Name?	1
2	Measuring the Earth	5
3	What are lines of Latitude and Longitude?	8
4	Scale and Direction (A Programmed Lesson)	13
5	Some effects of the daily rotation of the Earth and its annual revolution round the Sun	21
6	Longitude and Time. The International Date Line	27
7	Pressure and Wind Belts (A Programmed Lesson with an exercise on Ocean Currents)	33
8	The Measurement of Latitude and Longitude on the Earth's Surface (A Programmed Lesson)	43
9	Something about Weather	51
10	Something about Climate and Natural Vegetation	62
11	Something about Map Projections	69
12	On making a map or plan	74
13	On reading a map	78
14	Contour Lines (A Programmed Lesson)	83
15	About Geology and some land forms	90
16	About the Sea and the Oceans	100
17	A little about the Moon	106
18	What's more to do?	108
	Index	111

1. *What's in a Name?*

DEAR Lakshmi, Rudra, Shankar—or whatever your name may be—, have you ever thought what your name means? My mother's family name was Fletcher, derived from a French word meaning 'arrow maker' and many English and Parsi names are a clue to what an ancestor did: Goldsmith, Baker, Shepherd, Readymoney. Other names like Khandalawala and Bulsara tell the place the family came from as do many South Indian names. Most Indian first names are of religious origin. Lakshmi you will all know, but I have come across boys who had no idea that Rudra and Shankar were epithets of Shiva, meaning 'Terrible' and 'Benefactor'.

Now I want you to think of the meaning of the three words: Geography, Geometry and Biology. They come from Greek which, with Latin, is one of the ancient languages from which many English words are derived, just as many words in Indian languages are dervied from Sanskrit and Arabic. That is why, if you want to write clearly and exactly, if you want your meaning to be definite, it is useful to study classical languages, and if you can't do this you should anyway try to say what you mean shortly and clearly. Language should be exact. It is one of man's most important tools and tools should be kept sharp and clean.

I once read a note that said, 'Such a journey does not involve the necessity of obtaining a certificate of fitness.' This is the sort of language we read too often in newspapers and government publications. Can you make this sentence sharper and clearer? I suggest 'A certificate of fitness is not needed for such a journey'. Always try to be short and clear in what you write; but it is not always easy. For example, the words geography, geometry and biology no longer have their exact Greek meanings and some words in most languages come to be used with meanings a little different from those they started with.

Geos in Greek means 'the earth'. Photography has the same ending as geography. *Photos* is Greek for 'light' and if you study biology you may have heard of photosynthesis, the way in which green plants use the light energy of the sun to make glucose. *Graphos* is the Greek for 'writing' or 'drawing', so photography means a 'drawing with the help of light' (though now photographs can be taken in the dark on special films sensitive to rays we cannot see) and Geography means essentially 'drawing the earth' and though now it too has a wider meaning, this draws our attention to the importance of maps.

Geometry means 'measuring the earth', but the word has now acquired a meaning wider than just that; and Geology means 'a discourse' or 'words about the earth', just as Biology means 'a discourse about' or 'the study of living things'(—the Greek word *bios* means 'life').

The word Geology has not quite as wide a meaning now as you might expect. It is used for the study of the crust and rocks of the earth. It might have been a better word for what we now call Geography.

This little book is meant to help you understand and become interested in some of the important facts about the earth. Some people are frightened of physical geography and what they call mathematical geography, which is largely geometry. I want to try to remove the fear if you suffer from it.

I have called this chapter 1 because I wanted you to read it, and many people skip introductions, prefaces and forewords. If you want to think clearly I suggest you take an interest in words and always use your dictionary if you are not sure of a word's meaning. If you want to be a scholar in arts or science or medicine or geography, or for that matter in anything, the exact use of words is very important. If you have forgotten or do not know the meaning of any word used in this book, look it up in the index, which will tell you where to find it, and if it is not there use your dictionary.

Something to do after reading chapter 1

A suffix (from the Latin 'to fix beneath' or 'after') is a letter or syllable added at the end of a word; and a prefix is one added at the beginning.

Keep some pages of a note book to make, as you come across them, a collection of the names of Indian cities, towns, villages, districts and so on whose suffix or prefix tells you something about the place.

1. The following are all suffixes meaning 'city' or 'town': —pur, —puri, —purnam, —patam, —nagar, —nagore, —nagram, —ur, —or, —patti, —cherry, —shahr. For example: Vijayanagram means 'city of victory' and Pondicherry means 'new town' (Puducheri). You will find that in turning Indian names into English spelling, the words have often got changed. Cape Comorin comes from Kumari, the maiden Durga, and Kanpur used to be spelt Cawnpore!
2. Kot or Garh are suffixes meaning a fort. Add to your collection the names of places ending with either of these suffixes; for example, Kishangarh.

3. 'Hat' or 'hati' are suffixes meaning a market. Do the same for places ending with these suffixes; for example, Gauhati.
4. Do the same for places ending with —ganj or —gunge which means a 'store' or 'market' and —sar 'a lake', and —abad 'the abode' or 'dwelling place of'.
5. Places beginning with Rai—, Raj—, Raja—, Rani—, probably commemorate or do honour to some ruler. You should be able to collect many such names.
6. The prefix 'tiru'— or 'tri'— is from the Sanskrit Shri, 'holy' or 'sacred'. You can find many places beginning with these prefixes: for example, Trichinopoly is the English way of spelling *Tiru shila palli,* meaning 'sacred rock town'.

I got interested in Indian names as a result of reading *What's in an Indian name?* by Colonel Gifford, a pamphlet published years ago by the United Press in Delhi. I am afraid that it is now out of print. But if you could get hold of a copy, you would find all sorts of interesting names; for example, Malabar 'the hill country', Annamalai 'elephant hill', Calcutta from Kalighata, 'the bathing place dedicated to Kali', Hardwar from Haridwar (as most people still pronounce it) 'the gate of Vishnu', Poona or Pune from Punyapur, 'the city of purification', Bangalore 'the town of the bangalur bean', and so on.

2. Measuring the Earth

For more than 2000 years men have known that the world is a great ball, but, although Eratosthenes measured its size about 200 B.C., some people still thought it was flat, and in Europe Galileo (1564-1642) was abused and persecuted for saying that the world went round the sun, rather than that the sun revolved round it. We must remember the importance of not forgetting the truths discovered by those who lived before us, perhaps many, many years ago. Are you today as clever as Eratosthenes was more than 2000 years ago?

Before I describe how he measured the earth, I want you to understand the geometry he used for his calculations. If you already do understand what follows you must forgive me, but first glance at the next four paragraphs to make sure.

Eratosthenes knew that two parallel lines were always the same distance apart, and that the corresponding angles they made with any other line through them would always be equal.

In Fig. 1 *AB* and *CD* are parallel and the corresponding angles marked *C 1* and *C 2* are equal. If two lines are parallel the corresponding angles made by another line crossing them are always equal.

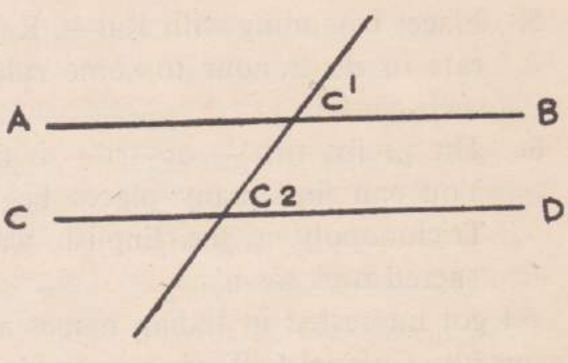


Fig. 1

Eratosthenes also knew that any straight line from the centre of a circle comes out through the circumference[1] at right angles to the tangent at the point where it comes out. A right angle, I am sure you know, is 90 degrees.

Any straight line from the centre of a circle to its circumference is called a radius[2] and Eratosthenes also knew that a radius produced would point to the zenith[3] of the place where it cut the circumference. If you are standing upright on a level piece of the earth, your legs point to the centre of the a —— x

---

[1] The words *circumference* and *tangent* are both derived from Latin. *Circumference* means 'that moves or goes around' and *tangent* means 'touching', a line that touches a circle at one point only.

[2] Another word derived from Latin, meaning a 'spoke' or 'ray'.

[3] The word *zenith* is derived from an Arabic word meaning the 'way of the head' and this can remind us of the debt owed by the West to the Arabs among whom much early learning was kept alive that had been lost to the West.

$a : x :: 360 : ?$

$? = \frac{x \times 360}{a}$

earth and your body from feet to head points to the zenith of the place where you are standing.

You have almost certainly heard that there are 360 degrees (the symbol for degree is °) in a circle. Have you ever wondered why 360 and not some more easy number like 100? The reason has to do with the time it takes the earth to revolve round the sun, roughly 365¼ days, and long ago men thought the earth revolved 1° each day. So now we use of the word 'degree' as a measure of the circumference of a circle or of the angle where two straight lines meet. The angle at *O* between *AO* and *CO* in Fig. 2 is 90° (what is called a right angle) or a quarter of the circle.

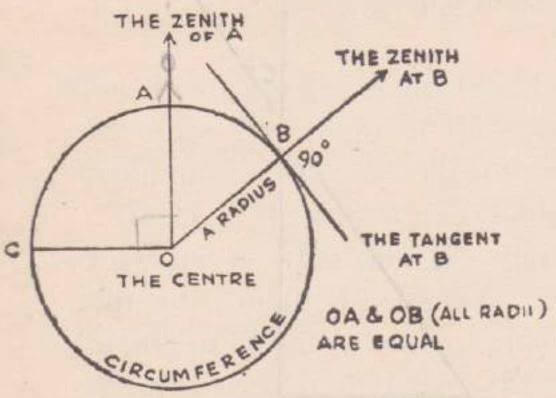


Fig. 2

Now we can describe how Eratosthenes measured the earth. He lived in Egypt and he noticed that the sun was in the zenith at Aswan at noon on a certain day. On the same date at the same time he measured the angle between the sun's rays and the zenith (called the zenith distance of the sun) at Alexandria. He thus got a figure like this

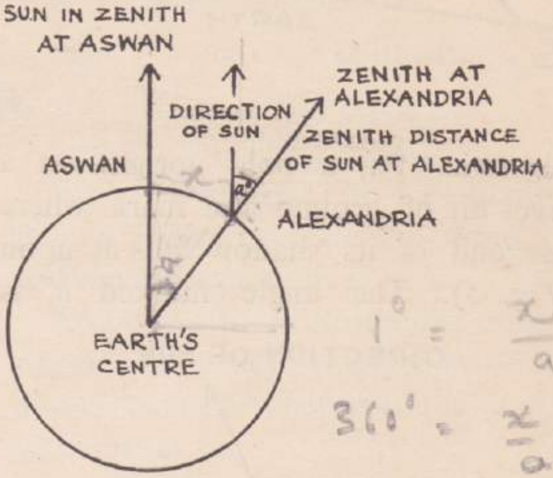


Fig. 3

$1^\circ = \frac{x}{a}$

$360^\circ = \frac{x}{a} \times 360^\circ$

$= \frac{x}{a} \times 90$

You may ask why the lines pointing to the sun from Aswan and Alexandria look parallel. They should, of course, meet at the sun, but the sun is so far off that by the time its rays reach the earth they are so nearly parallel that we may take them to be so. If you look at Fig. 4, you can see that in position S, the sun's rays are nowhere nearly parallel, but in position N they are more nearly so. Now the sun is so far off that we cannot draw a figure on a sheet of paper that would show the earth and its relative size and distance from the sun, but you can imagine that as N gets further and further away the sun's rays would become more and more nearly parallel.

You may also ask how Erastosthenes measured the zenith distance of the sun at Alexandria. If the sun is visible you can measure its zenith distance

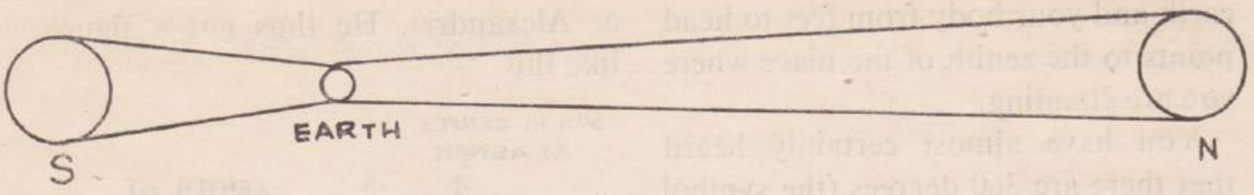


Fig. 4

like this. Put a pole upright on a level bit of ground and mark where the end of its shadow falls at noon (*Fig. 5*). The angle marked a° is the zenith distance of the sun. How do you measure this angle and how do you know it gives the zenith distance of the sun? This involves a bit more geometry and if you know it already only glance through the next two paragraphs.

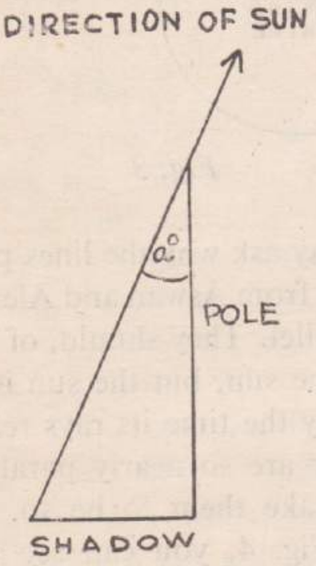


Fig. 5

You would have to make a drawing of the pole and shadow to scale, that is, if the pole is one metre high above the ground, draw a line to represent it 10 cm. long. Then at right angles draw another line to the same scale (that is divide its actual length by 10), then measure $\angle a$ (the sign for angle is $\angle$) with a protractor, the instrument used for measuring angles. $\angle a$ is same as the zenith distance of the sun because it is vertically opposite to it and vertically opposite angles are equal. If you know how to prove this, leave out the next paragraph.

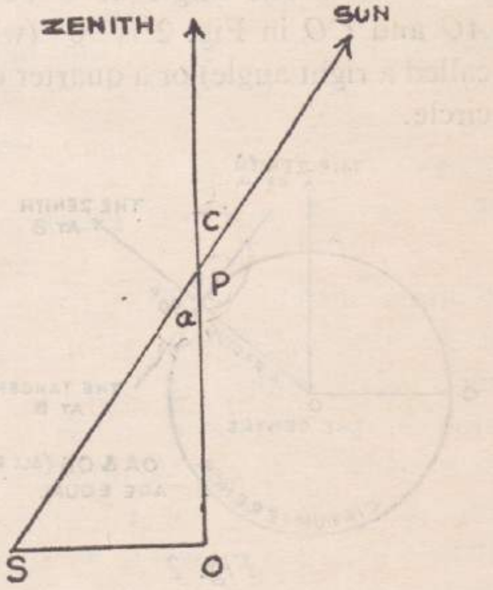


Fig. 6

In Fig. 6 *OP* is the pole pointing to the zenith, *OS* is the shadow and *SP* points to the sun. $\angle c$ between the zenith and the sun's rays is the zenith distance of sun. Now $\angle c$ plus $\angle P$ make a straight line, or 180 degrees and $\angle P$ plus $\angle a$ make another straight line. We get therefore what is called an equation:

$\angle c + \angle P = \angle P + \angle c$

Take $\angle P$ from both sides of the equation and the remainders $\angle c$ and $\angle a$ are equal. These are known as vertically opposite angles.

This chapter is getting rather long. So let us get back to Eratosthenes, and look again at Fig. 3. He had measured the zenith distance of the sun at Alexandria (a°). He knew that the smaller angle shown at the earth's centre corresponded to the zenith distance at Alexandria because the sun's rays were parallel, therefore, it equalled a°. He also measured the distance from Aswan to Alexandria; let us call it x kilometres and do a little Algebra.[1]

If a° equals x kilometres

then 1° equals x/a kilometres

$\therefore$ 360° equal $\frac{360x}{a}$ kilometres

We have turned a into 1 by dividing it by a and so must do the same to x to keep the equations true.

According to Eratosthenes' measurements and calculation the world was about 40,000 kilometres round, and he was not far out.

---

[1] Another word derived from Arabic and meaning using letters and symbols to find out what happens to numbers when we play about with them.

Something to do after reading chapter 2

Stick a pole upright in any level bit of ground on which the sun shines all day.

1. Measure the length of the shadow of the pole every hour for one day from morning to evening and, by making drawings to scale, find the zenith distance of the sun at each hour.
2. Find out at what time the shadow is shortest (it will be about 12 o'clock, but not exactly 12, unless you are on the meridian from which Indian Standard Time is taken, which will be explained later) and measure it once a week at that time for as many weeks as you can, and then find the zenith distance of the sun each week and note the date. The easiest way to find when the shadow is shortest is to mark the end of the shadow about 10-30 a.m. and then draw a circle round the pole with the length of the shadow as radius. Come back about 2 p.m. (earlier still if the shadow has already covered your circle) and wait till the shadow again touches the circle you have drawn. Bisect the angle made by the two shadows and the shortest shadow should be along that bisector—but check up that it is; if it is not, something has probably gone wrong with the drawing of your circle.

3. *What are lines of Latitude and Longitude ?*

If you are sitting in a classroom the teacher, if he is like me, apt to forget people's names, might refer to you as the boy in the third row from the front and the sixth file from the left. That is to say you are named by your position which is fixed by the meeting place of two named lines, rows and files. This is what lines of latitude and longitude are used for—to name positions on the earth's surface.

If you want to understand easily about the world, try to get hold of a globe representing the earth. Any cheap one will do, or even an old ball with a knitting needle or a piece of stiff wire stuck through its centre and coming out at two sides. Also, always have your pencil and some paper ready to draw your own diagrams and figures. What you see and draw for yourself is easier to understand and remember than what you read.

The earth is not quite a true ball, for it is a little flattened at the top and bottom, what are called the North and South Poles, the two places where your piece of wire comes out of your ball. A true ball is called a sphere, and the earth is called an oblate spheroid, a name you can forget for the present, as, until you come to more advanced geography, you can take the world to be a sphere, a word derived from the Greek for a ball.

A word you must remember is axis. This is an interesting word because it reminds us of how a number of words in many different languages are much alike and seem to have had the same ancestor. *Axis* is Latin, *aksha* is Sanskrit, *axon* is Greek, and there are very similar old Norse and German words. You know what the axis of a wheel is—the rod or point round which the wheel revolves. The world's axis is an imaginary line about which the world spins or rotates and is represented by the piece of wire through your ball.

Another word to know is equator, derived from the Latin for 'equal'. This is an imaginary line round the middle of the world exactly between the North and South Poles, dividing the world into two halves or hemispheres.[1]

The equator is an imaginary line on the earth's surface, but on a globe or map it is drawn. The problem for map makers was how to draw a network of named lines by using which positions of places could be fixed on the earth's surface.

Lines or parallels of latitude were not difficult. Map makers started with the equator in the centre and then drew lines parallel to it until they reached the North and South Poles, and these lines were named by the number of degrees between each.

---

[1] *Pole* is from the Greek for a pivot and *hemi* is the Greek for half.

Imagine your ball cut down the axis, like an apple down the core, and divided into two hemispheres.

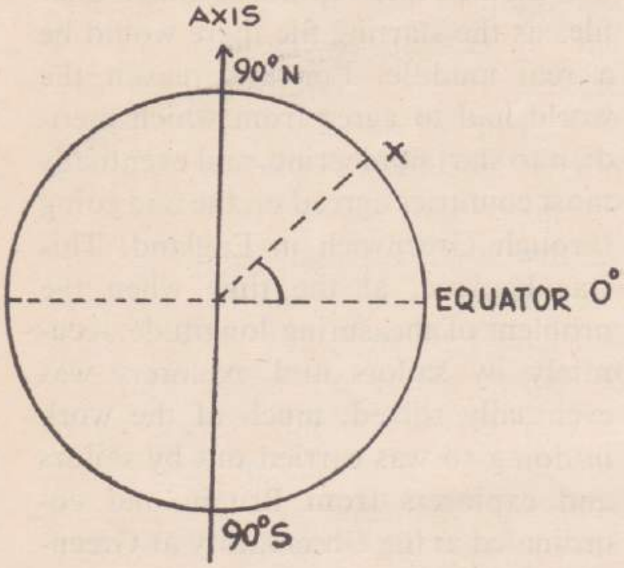


Fig. 7

If the equator is called 0°, then the North Pole will be 90° N. and the South Pole 90° S. and the place marked *x* will be a certain number of degrees N. depending on the angle marked in Fig. 7. I hope you will wonder how any one could go to the centre of the earth to measure this angle. The answer is that it can be measured on the surface of the earth from the rays of the sun (this is what Eratosthenes knew), or from the Pole Star, and how this is done will be explained in chapter 8. What you need to know now is that parallels of latitude, lines running East and West, can be imagined on the earth's surface and drawn on maps. I have drawn a few on Fig. 8, and these correspond to the rows in a classroom with which we started this chapter, and can be used for fixing position in degrees north or south of the equator. Parallels of latitude will become shorter and shorter as you go north or south from the equator, till they become points at the poles. A low latitude is near to the equator and a high latitude near to the poles.

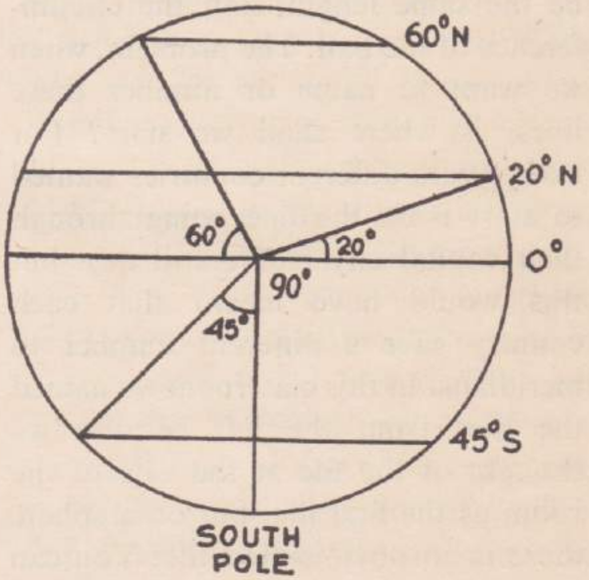


Fig. 8

The other lines, the files, called meridians of longitude—a name I will explain later—were more difficult to deal with. It was easy to imagine lines running round the globe from the North Pole to the South making angles at the poles, but which was to be called 0°, and how were the angles to be measured? I will first explain how the meridians are named and measured on a map or figure, and leave till chapter 8, the more difficult business of measuring their angles on the earth's surface. It took man a long time to be able to do this (he had to wait till he had invented a clock that would keep accurate time at sea) so we too will wait a bit.

Now take your ball and draw any line on it from the North Pole to the South. All lines that you can draw will be the same length, half the circumference of the ball. The problem, when we want to name or number these lines, is where shall we start? For many years different countries wanted to start from the line going through their capital city (some still do), but this would have meant that each country gave a different number to meridians. In this classroom we named the files from the left because we thought of the file at the side of the room as the first file, but on a sphere there is no obvious first file. You can imagine what would happen if the head of the class sitting in the third file from the left, claimed that his must be the starting file, and the captain of football in the fifth file said that files must be numbered from his. If they were both in the front row, the student between them would be called 'row one, one to the right' by those who agreed with the head of the class, and 'row one, one to the left' by the footballers.

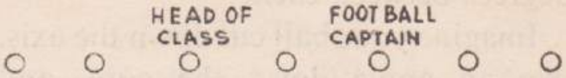


Fig. 9

If all the other captains claimed their files as the starting file there would be a real muddle. For this reason the world had to agree from which meridian to start numbering, and eventually most countries agreed on the one going through Greenwich in England. This was because, at the time when the problem of measuring longitude accurately by sailors and explorers was eventually solved, much of the work in doing so was carried out by sailors and explorers from Britain and co-ordinated at the Observatory at Greenwich.

Now we can see how meridians are numbered. Turn your ball, or the

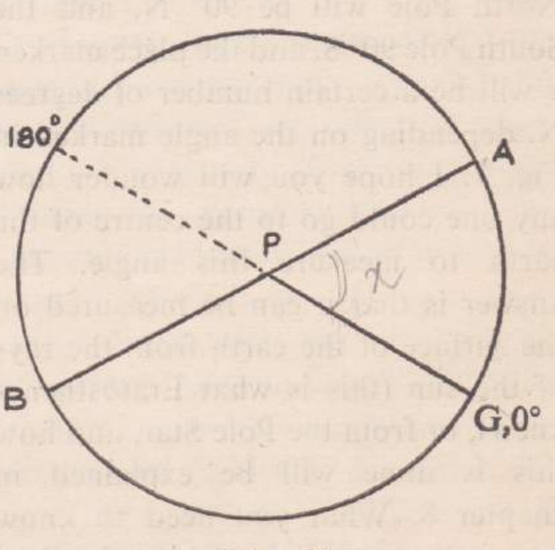


Fig. 10

apple cut along the equator, so that you are looking down on the North Pole, and draw a line PG to represent the meridian going through Greenwich.

The name of the meridian PA will be the number of degrees of the $\angle APG$ east of Greenwich and of meridian PB the number of degrees of the $\angle GPB$ west of Greenwich. How these angles are measured on the surface of the earth, I will, as I have said, explain later, but you can measure them for yourself on the figure, and you will see that you can only go as far as 180° either east or west, and that each full line right round the world will be so many degrees (let us say X°), east of Greenwich on half of the world, and $(180—X^\circ)$ west of Greenwich the other half of the world if we imagine 180° and 0° dividing the world into two halves. In Fig. 10 you can see only the northern hemisphere, but you can turn your ball or apple so as to see the southern hemisphere as well.

This is an example of a great difficulty for maps makers. Maps are usually flat on sheets of paper, but the world is spherical, and it is impossible to make an exact map of a large part of the earth's surface. Geographers, therefore, use various methods known as map projections, some of which will be described later, to show large areas. In some of these all parallels of latitude are shown as the same length, though you know they grow shorter the nearer they are to the poles, and meridians are sometimes shown as parallel north and south lines although you now know that they meet at the poles. But a network of parallels and meridians, however drawn, can be used to show the position of any place on the earth's surface. In most atlases, and you should always have one by you, you will find the latitude (always given first) and the longitude of places given in the index[1] so that you can find them on the page of the atlas referred to. Each degree is divided into 60 minutes and each minute into 60 seconds, but usually only the degrees and the minutes will be given. In my atlas, Delhi is given as 28.35 N., 77.5 E. so when I look for it, I look just over half a degree north of parallel 28 N. and a tiny bit further east than meridian 77 E. Quito is 0.17 S., 78.26 W. so I look for it just south of the equator and nearly half a degree further west than 78° W. *The School Atlas* published by the Survey of India does not give the latitude and longitude of a place in the index but tells you the 'square' in which to find it, and having found it you can judge its latitude and longitude from the parallels and meridians drawn on the map. Now in Figs. 11 and 12 think out the latitude and longitude of the places marked and write them down. Then look at the answers below and see if you have got them right.

---

[1] From the Latin for forefinger or informer.

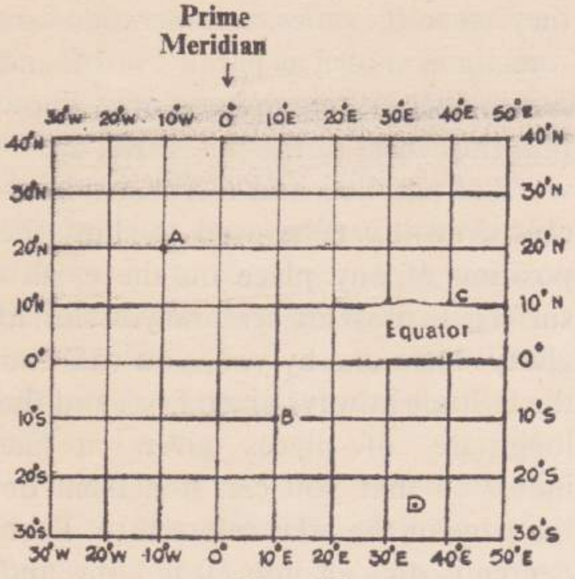


Fig. 11

Answers:

Fig. 11

A	20 N	10 W
B	10 S	10 E
C	10 N	40 E
D	25 S	35 E

Fig. 12

W	30 N	60 E
X	45 S	30 W
Y	15 S	0°
Z	22 S	45 E

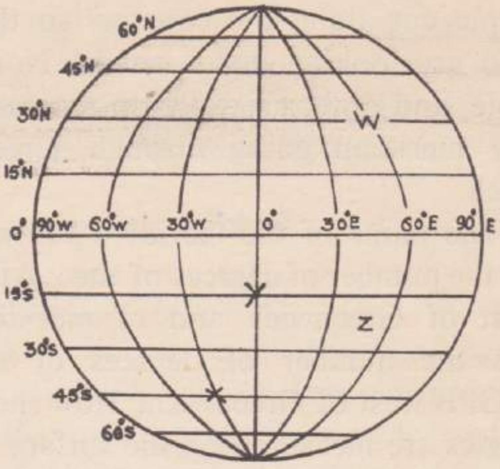


Fig. 12

I wonder if you have ever wondered why an atlas is called by this name. Atlas was a Titan or giant whom the Greeks imagined as holding up the heavens on his shoulders. He lived in the Atlas mountains in Africa. When Mercator published his father's maps in 1595 he put on the title page a picture of Atlas with the world on his back, and since then a book of maps has been called an atlas.

Something to do after reading chapter 3

1. If the index of your atlas gives the latitude and longitude of places, look these up for Chandigarh, Lucknow, Raipur, Hyderabad, Bangalore and Ahmedabad and find them on a map of India.
2. If the index of your atlas only tells you the square in which to find a place, find these places on the map, and write down what you think their latitudes and longitudes are. Then borrow an atlas that gives their latitudes and longitudes and see how nearly right you were.
3. Do the same as (1) or (2) for Moscow, Peking, Canberra, Cairo, New York and Brasilia.

4. Scale and Direction

(A Programmed Lesson)

I have been writing about north, south, east, and west because I am pretty sure you know what they mean. Remember that wherever north is, east is at right angles to it the way the hands of a clock go round and that the sun rises in the east and sets in the west and you won't go wrong.

This chapter, I shall write as a programmed lesson so that I hope you will be able to read and understand it without having to ask questions of your teacher. The answers to the questions asked are given at the end. Look at them only one at a time covering up the ones you have not come to. If your answer is correct, go on. If you get it wrong, think again and you will probably be able to see why, but if you cannot then you must ask for help. What you do for yourself and understand, does much more good to you than getting the right answer with help and not understanding it. Marks are only meant to help you judge yourself and to help the teacher to know how successful his teaching has been. That is why getting marks by unfair means in class does you no good in the end.

Now, suppose you wanted to describe to a friend a cricket ground on which you had watched a match. You might write to him something like this: 'The ground was 120 metres square, with a matting wicket in the centre lying north to south, and a pavilion at the south-west corner of the field'. Or you might have sent him a plan or sketch map of the field and if you had not read this chapter you might (though I hope not) have drawn it,

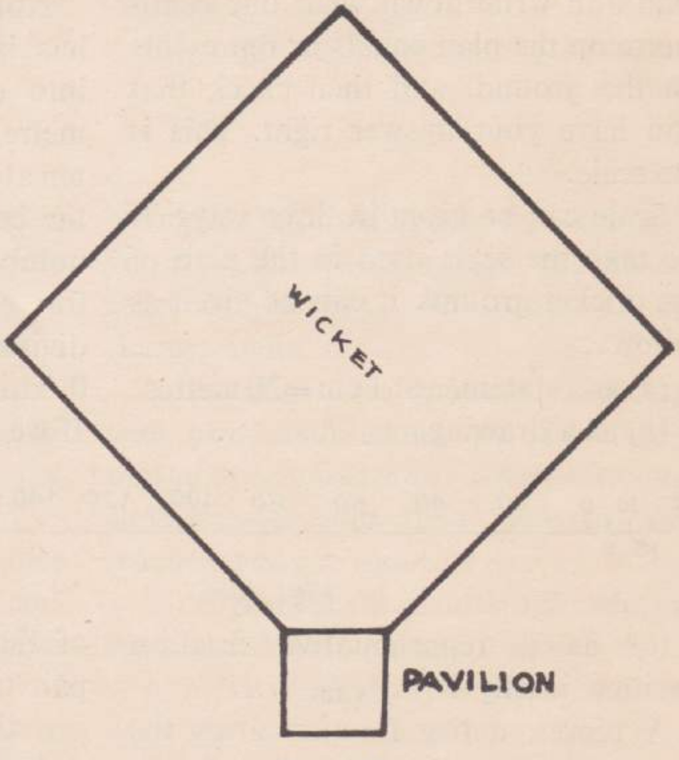


Fig. 13

sitting in the pavilion, like this.

Look carefully at this plan, and you will find that it fails to give two very important bits of information given in your description. It does not tell us the (*a*) — of the ground, and it does not tell us the (*b*) — in which the wicket lies and whether you would have the sun in your eyes sitting in the pavilion or not.

1. Write down the two words missing above and then look at the answers at the end of the chapter and see if you have got them right.

Thus we see that, to be complete, all plans or maps must have a scale, and a sign showing direction.

2. Measure a side of the ground (you know it is 120 metres) on the plan and write down what one centimetre on the plan equals or represents on the ground, and then check that you have your answer right. This is the scale.

Scale can be given in three ways. If we take the scale used in the plan of the cricket ground, it can be given as follows:

(*a*) as a statement : 1 cm=20 metres

(*b*) as a drawing

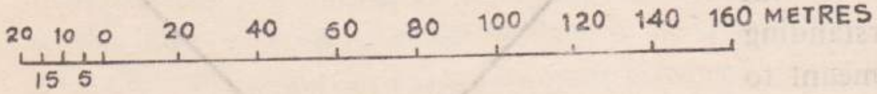


Fig. 14

(*c*) as a representative fraction (written briefly R.F.) $\frac{1}{2000}$

A representative fraction gives the proportion or ratio of the plan or map to the actual thing, that is here the number of times the actual ground shown in the plan, is bigger than the plan. In other words, one of any measurement on the plan is 2000 of that same measurement on the ground. This is useful, particularly if the statement and drawing are in units of measurement with which you are unfamiliar. Suppose you wanted to state the size of the ground in yards instead of metres, you measure one side in inches, and you find it to be 2.3″. This will represent 2000 times 2.3 inches on the ground. (*Note*—My measurements are not exact, but as accurate as I can make them.)

3. How many yards is that to the nearest yard?

Notice how the drawing of the scale has been made. The line is divided into centimetres, because one centimetre is the unit of the scale; 0 is written at the *end* of the first division not at the beginning. The other divisions are numbered forwards from 0, 20 metres for each centimetre, but the first division is sub-divided *backwards* from 0. This is done to save time and trouble. If we had put the 0 at the beginning of the line we should have had to sub-divide every centimetre of the scale.As it is, when we use a pair of dividers to measure distances on the drawn scale we put the point of the right arm of the dividers on the 20 metre division just smaller than the distance we want to read, and then read the extra metres from the point of the left arm of our dividers in the first division of the drawn scale. For instance, if we want to know what is the actual distance from *A* to *B* we read it in this way:

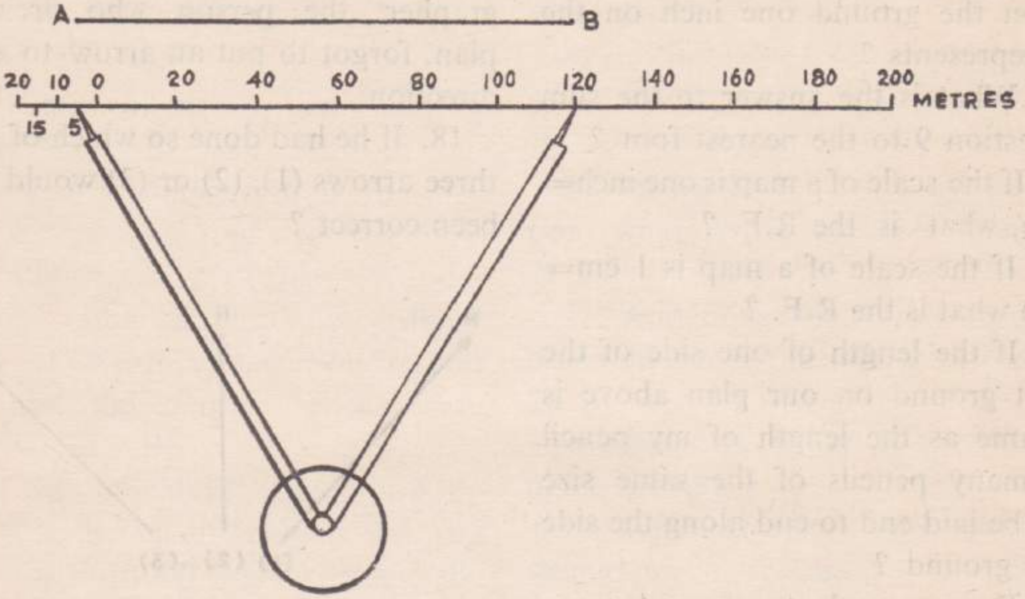


Fig. 15

We open the dividers the exact distance from *A* to *B* and place them on the scale like this.

We can then see that the distance is 125 metres.

4. Now use your dividers (or a pair of compasses with a sharp point to the pencil will do) to find:

(a) the distance diagonally across the field from the left hand corner to the right hand corner and write it down.

(b) the distance from the centre of the ground (which would seem longer if you had to walk it after getting out first ball !) to the pavilion.

Look at the answers I have given. They are not exact, but as near as I can get them with my instruments. No measurement that you will be able to make is likely to be exact, but if you have got them within 5 metres of mine you have done well enough. But be as exact as you can, and always use a sharp pencil.

Now a few more questions to make sure you understand all about representative fractions. Write down each answer and then look to see whether you are right.

5. What is the R.F. of a map whose scale is 1 cm = 1 km ?

6. What is the R.F. of a plan whose scale is 1 inch = 1 yard ?

7. If a map has an R.F. of $\frac{1}{10000}$,

how will you find out how many metres on the ground 1 cm on the map represents ?

8. Write down what you find when you have thought out the answer to question 7 as a statement of scale.

9. If a map has an R.F. of $\frac{1}{100000}$ how would you find out how many feet on the ground one inch on the map represents ?

10. What is the answer to the sum in question 9 to the nearest foot ?

11. If the scale of a map is one inch= 1 mile, what is the R.F. ?

12. If the scale of a map is 1 cm= 10 km what is the R.F. ?

13. If the length of one side of the cricket ground on our plan above is the same as the length of my pencil how many pencils of the same size could be laid end to end along the side of the ground ?

14. Draw a scale to show 4 cm= 100 metres.

15. Draw a scale to show 1 inch= 1 mile with sub-divisions for furlongs (8 in a mile).

16. What is the R.F. of the scale stated in question 14 ?

17. State how many yards 1 inch in a map shows on the ground if the scale of the map is the answer to question 16.

Give this to the nearest yard.

If you have answered all these questions correctly, even if you have made mistakes but have understood where you went wrong you should have no more difficulty with these scales.

We now come to *Direction*. In the written description of the cricket field the direction was given: we were told that the wicket lay roughly north and south and that the pavilion was in the south-west corner of the field. But when the plan was drawn the cartographer[1], the person who drew the plan, forgot to put an arrow to show direction.

18. If he had done so which of these three arrows (1), (2) or (3) would have been correct ?

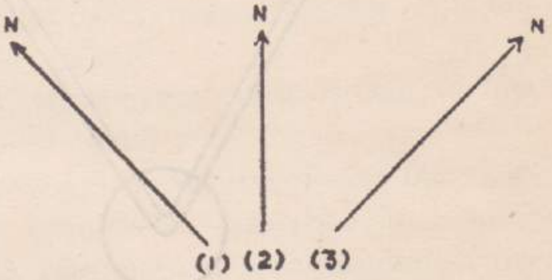


Fig. 16

If your answer was (2) you forgot that the pavilion was in the south-west corner of the field and you were caught by thinking that north is always at the top of the paper. It normally is, but it need not be so.

19. In what direction are you facing if you look straight across the field from the pavilion ?

Now we must consider the different ways of naming direction. For a long time this was done by the points of the mariner's compass : *N*, *N* by *E*, *NNE*, *NE* by *N* and so on. There are 32 points in the mariner's compass, but there are 360 degrees in a circle, so between each point of the compass there are 11°15″. [A degree is divided into 60 minutes shown by the sign ′ and each minute into 60 seconds shown by the sign ″.]

---

[1] Map-drawer, from the French *'carte'*, a chart or map, and the Greek word for drawing that we have already met in geography.

20. What calculation gives us $11\frac{1}{4}$ degrees ?

21. This is too inaccurate for modern direction-finding, so we now name direction by degrees. We do, however, often still use the cardinal[1] points of North, East, South, and West and the points between—*NE*, *SE*, *SW* and *NW*.

One way of naming direction is by what is called a three-figure bearing from North or 000 degrees, round the compass clockwise to North again, 360 degrees. Thus East is 090°, South 180° and West 270°.

What, in three-figure bearings, are (1) *NE*, (2) *SE*, (3) *SW*, (4) *NW* ?

22. If a ship is sailing north and alters course 5 degrees to starboard (to the right) in what direction, in a three-figure bearing, will it be sailing ?

23. If a plane is flying south and alters course 10 degrees to port (to the left), in what direction, in a three-figure bearing, will it then be flying ?

There is another way of naming-direction which you ought to know about. In this you start with whichever is nearer to the direction, North or South first, and then say how many degrees the direction is to the East or West.

For example, *NE* is *N* 45 *E*, *SE* is *S* 45 *E*, *SW* is *S* 45 *W* and *NW* is *N* 45 *W*.

24. Using this way of naming direction, what is the answer to question 22 ?

25. And how would you name the direction that is the answer to question 23 ?

26. What is *N* 30 *W* as a three-figure bearing ?

27. What is 260° named in the second way described ?

28. Look at the rough sketch map on the next page. With your protractor measure the directions of Ajmer, Bikaner, Agra, Delhi from Jaipur and write down each direction in the two different ways described above of naming directions.

29. Then with your dividers or compass and using the drawn scales, measure the direct distances of Ajmer, Bikaner, Agra and Delhi from Jaipur and write these down in kilometres and in miles.

30. If you want to show that you are really clever check the drawn scales against the R.F.

---

[1] The word 'cardinal' comes from the Latin *'cardo'* a hinge, and means something on which things hinge, something important.

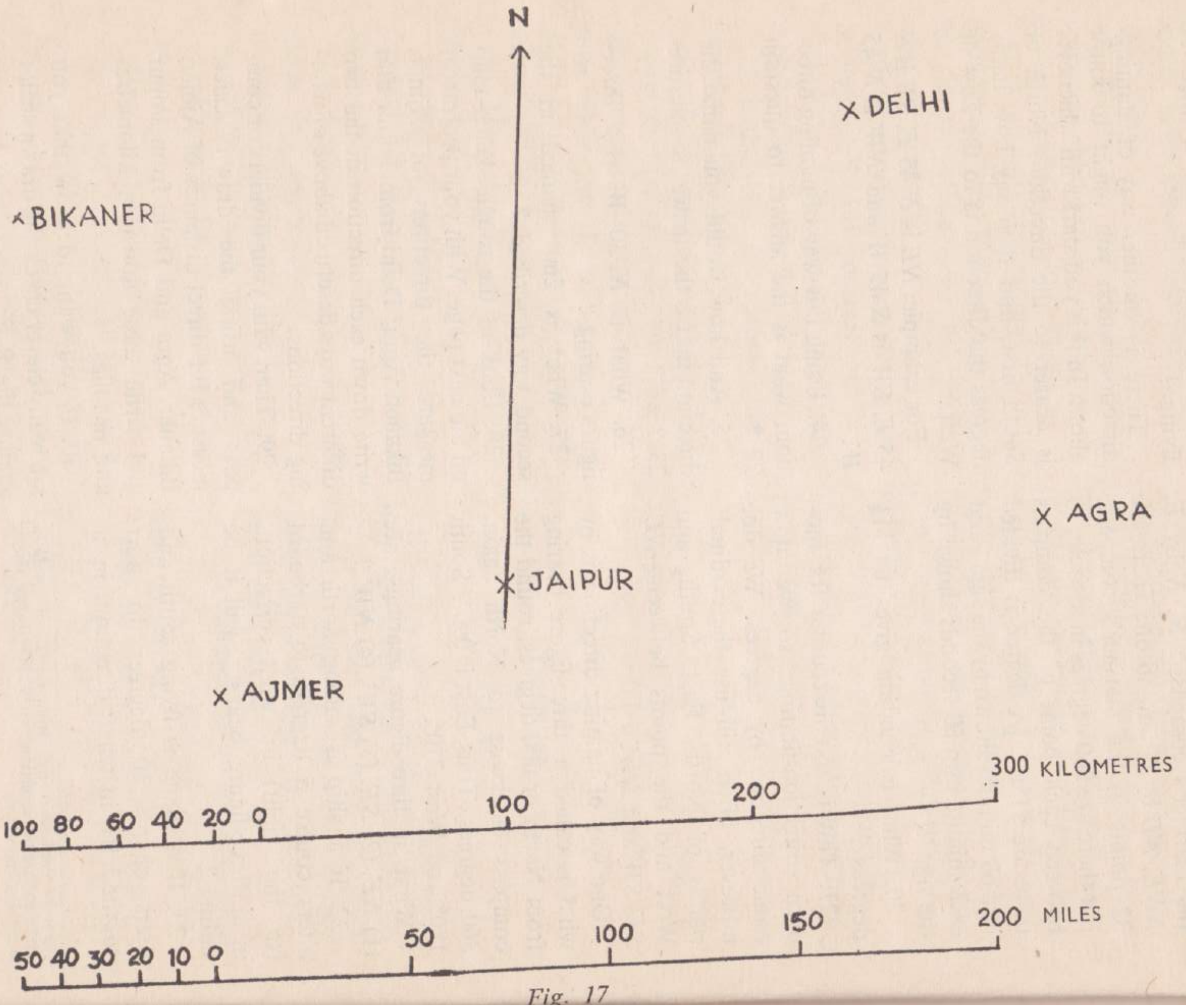
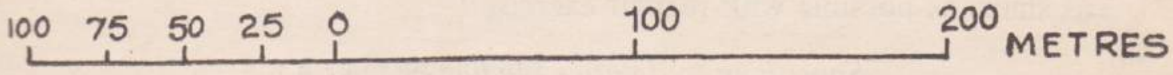

N
X DELHI
X BIKANER
X AGRA
X JAIPUR
X AJMER
100 80 60 40 20 0 100 200 300 KILOMETRES
50 40 30 20 10 0 50 100 150 200 MILES

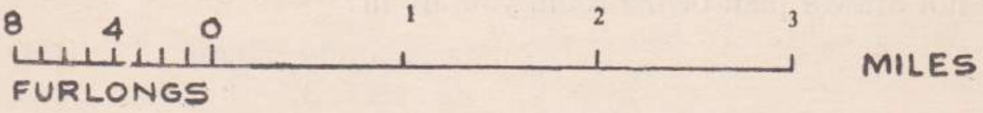
Fig. 17

Answers to the questions in chapter 4

1. (*a*) Size (*b*) Direction (or alignment or bearing)
2. 1 cm=20 metres
3. 128 yards
4. (*a*) 170 metres (*Note:* If you know the theorem of Pythagoras and how to find a square root you can work this out instead of measuring it; but don't worry unless you want to test my accuracy).
(*b*) 77 metres
5. 1/100,000
6. 1/36
7. Divide 1000 by 100
8. 1 cm=10 m
9. Divide 100,000 by 12
10. 1″=8333 feet
11. 1/63360
12. 1/1,000,000
13. 2000
14.



15.



(*Note:* In questions 14 and 15 your drawing is not complete unless you have remembered to write down the distances shown above).

16. 1/2500
17. 69
18. (1)
19. NE
20. 360 divided by 32
21. (1) 045° (2) 135° (3) 225° (4) 315°
22. 005°
23. 170°
24. N 5 E
25. S 10 E

26 330°

27. S 80 W

28. Ajmer S 67 W or 247°   Agra N 83 E or 083°
Bikaner N 55 W or 305°   Delhi N 35 E or 035°
If you are within 3° of the answers given that is reasonably accurate.

29.

Ajmer	128 km	80 miles
Bikaner	245 ,,	155 ,,
Agra	220 ,,	140 ,,
Delhi	230 ,,	145 ,,

If you are within 5 kilometres or 3 miles of the answers given that is reasonably accurate.

30. If you measure the drawn scale of kilometres you find 4 cm = 100 km. ∴(the sign for therefore) 1 cm = 25 km and the R.F. 1/2,500,000 is correct. But if you measure the drawn scale of miles you find 1·25 inches = 50 miles or 316800 inches, whereas according to the R.F. 1·25 inches should equal 3125000 inches or approximately 49·3 miles. So the drawn scale is a little inaccurate—something over half a mile in every 50 miles. I did my best with a bazaar ruler and we must always remember that the accuracy we can achieve depends upon the tools available, therefore, keep your brain as sharp as possible with regular exercise !

Something to do after reading chapter 4

Why not draw a plan of the room you are in?

5. *Some effects of the daily rotation of the Earth and its annual revolution round the Sun*

Sol is the Latin word for sun, and the earth belongs to what is called the Solar System. The sun is a star, and the earth one of its planets (from the Greek word for 'a wanderer') that revolve around it. There are several hundred planets of which the easiest for us to see are Jupiter, Venus and Mars, called in Hindi Brihaspati, Shukra and Mangal. The moon revolves round the earth, and while the light from the sun and stars is direct, that from the planets, their moons or satellites (from the Latin for 'an attendant') and our moon is reflected from the sun. [For more about the moon see chapter 17.]

The sun is the source of the heat and light by which we live. Though Mars may have some sort of primitive vegetable life, the other planets are too hot or too cold, or their atmosphere[1] is too poisonous for life, as we know it, to exist. The sun holds its planets revolving round it by gravity, while they are kept from falling into the sun by the speed at which they revolve. The same control is exercised by the planets over their moons.

For many centuries (from the Latin for one hundred) man thought that the earth was the centre of the universe, of all existing things, and that the sun went round the earth. It was obvious, you could see it doing so; but if you have ever sat in a train in a station and looked out of the window at a train on the next line to yours, you may have thought that your train had started whereas, in fact, it was the other train that was moving. Our eyes can deceive us.

In the early civilizations of Babylon, Egypt, and China people still thought the earth was flat. It was the Greeks who realised it was spherical, but even they thought it was the centre of everything, and that the sun and stars revolved around it.

For centuries men had been making observations of the apparent changes in position of the sun and moon and stars, and if you want to arrive at the truth, be a real scientist, you too must always be observing and asking yourself the reasons for what you observe. Some parents and even teachers get tired of being asked 'Why?' 'Why ?' 'Why ?' But they should try to be patient and answer the questions (and not be afraid of saying 'I don't know' if they do not). It is by observation, enquiry, recognition of something you don't understand, and thought, that mankind has learned more and more of the truth. You probably know the story of the discovery of penicillin, how Dr Alexander Fleming noticed an unexpected effect of a mould that had accidentally got into some bacteria he was experimenting with. He asked himself 'Why ?' 'What has happened ?' And ten years later other scientists, working on his observations, were able to produce a great life-saver.

---

[1] From Greek words meaning a ball of vapour, so the gases surrounding heavenly bodies.

In Europe a Pole, Copernicus (1473-1543), about the time when Babar founded the Mogul Empire, came to the conclusion that the earth moves round the sun and not the sun round the earth, and a hundred years later the German, Kepler (1571-1630), working on observations made by the Dane, Tycho Brahe (1546-1601), after nine years of thought and mathematical calculations, worked out laws showing how the planets move round the sun in ellipses—regular ovals, not circles.

Now, from photographs taken from rockets and from the moon, man can see that the earth is not flat, but it was only in 1882 that the Catholic Church allowed its followers to read the works of Copernicus. Truth or fact is not always easy to find, and when it is found, it is not always easy to recognise. I want now to describe some of the facts that mankind has found and recognised after thousands of years of observation and thought.

First, there are some words that I must define. A *plane* as you probably know is a level surface like the top of a table, but it can also be an imaginary surface. If you take an apple to represent the earth and cut it in halves across the core along its equator then you see the plane of the equator exposed—the surface you cut through.

The next word is *ecliptic*, another Greek word for the sun's apparent orbit, which is a Latin word meaning 'wheel', and the plane of the ecliptic is the imaginary plane in which the earth revolves round the sun once a year in an ellipse. The earth also rotates once round its axis every 24 hours: not always exactly 24 hours, but you must wait to learn why 'not exactly' because it's a complicated business.

Then there is a very important fact you must remember. The earth's axis is inclined to the plane of the ecliptic at $66\frac{1}{2}^\circ$. Fig. 18 shows you the effect, of rotation, and Figs. 19 and 20 show

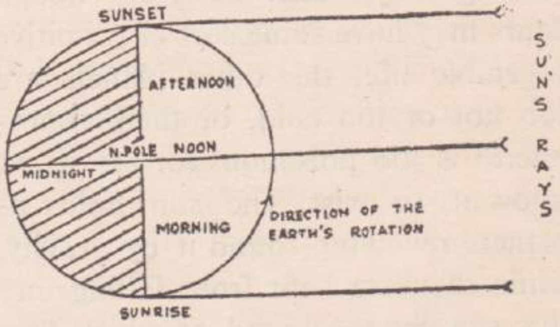


Fig. 18

how summer and winter are caused by the earth's revolution round the sun and by this inclination of the earth's axis, and why the tropics and arctic and antarctic circles are where they are.

In Fig. 18 you must imagine yourself looking down on the North Pole on a day (there are only two in the year as will be explained later) when the sun is in the zenith at the equator. I have drawn four meridians and now I will explain the meaning of that word. It comes again from Latin and means middle of the day. All places on the same meridian will have midday or noon at the same time, and that is why N or S lines from the pole to the equator are called meridians. As the world rotates each of these meridians will move round anti-clockwise. The one in the figure shown as at noon will move to sunset, then to midnight, then to sunrise and so back to noon on the next day. When the sun is in the zenith at the equator, everywhere on the earth there is twelve hours light and twelve hours darkness, and the line dividing day and night, called the shadow circle, passes through the poles. But, as I have said, the sun is not in the zenith at the equator more than twice a year, and that is why most of the world sometimes has shorter days and longer nights and at other times longer days and shorter nights. Fig. 19 will help to explain this, but first there are two new words for you to understand: *equinox* and *solstice*.

An equinox (Latin for 'equal night') is when the whole earth, as in Fig. 18, has 12 hours of light and 12 hours of darkness, or equal night and day. This happens twice a year, on about March 21st and September 22nd. Solstice (again Latin, meaning the 'standing sun') is when the sun appears to pause in its apparent journey from north to south and then from south to north. This apparent movement of the sun is, as you will now I hope understand, the result of the earth's actual movement, its revolution round the sun. The solstices are on about June 21st and December 22nd.

Fig. 19 shows the earth in relation to the sun's rays at the June and December solstices looking at the earth across the plane of the ecliptic. The earth, of course, is so far from the sun that we cannot put the sun into the picture but its parallel rays are shown and the actual distance between the positions of the earth at the solstices is roughly 300,000,000 km. At the June solstice the North Pole is pointed most toward the sun and at the December solstice most away from it. In June the northern hemisphere has long days and short nights (mid summer) and the southern hemisphere short days and long nights (mid winter) and in December the northern hemisphere has mid winter and the southern mid summer. At the equator night and day are always 12 hours each.

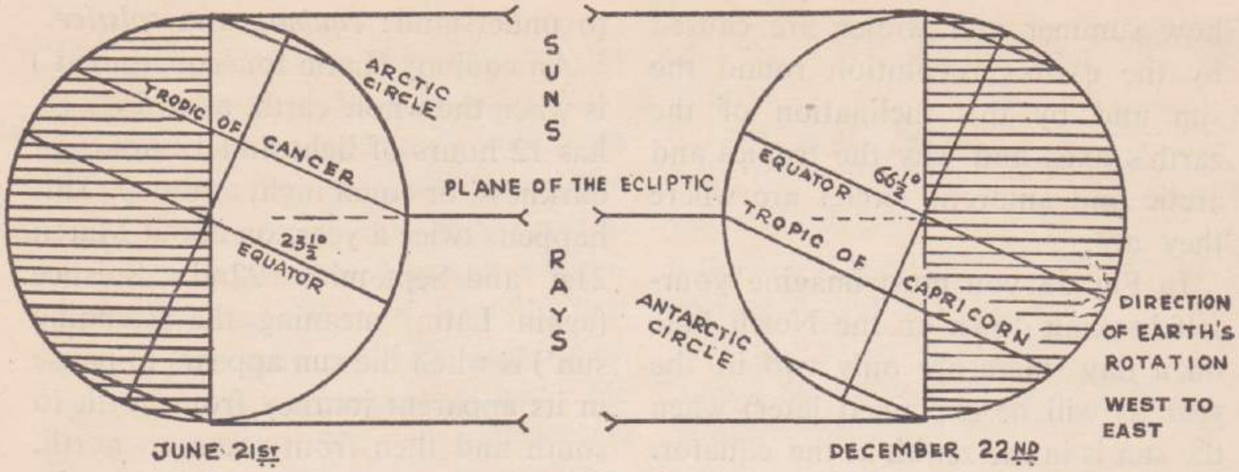


Fig. 19

The Tropic of Cancer is the farthest north that the sun is ever in the zenith and the Tropic of Capricorn the farthest south. On the Arctic and Antarctic Circles there are 24 hours light or darkness at the solstice and at the poles there are six months of light and six months of darkness, except for the twilight, the light from the sky when the sun is below the horizon.[1] Since the earth's axis is inclined at $66\frac{1}{2}^\circ$ to the plane of the ecliptic, the angles between the equator and the shadow circle to the Arctic and Antarctic Circles are $66\frac{1}{2}^\circ$ and that is their latitude, and the angles between the equator and the tropics are $23\frac{1}{2}^\circ$ which is their latitude.

What Fig. 19 does not show is what happens at other times of the year, particularly September and March. This is because the earth ought to be shown behind and in front of the picture, so I must try to draw another picture, but what the publisher will say I don't know, for all these illustrations have to have blocks made to print from and cost a lot of money.

For Fig. 19 we had to imagine ourselves looking across the plane of the ecliptic; for Fig. 20 I want you to imagine yourself away in some distant star looking down on the plane of the ecliptic.

The circle that you would see is a circumference of the earth, but not the equator since the earth's axis will be tilted at $66\frac{1}{2}^\circ$ to the plane of the ecliptic and, of course, you would have to wait a year in your star to see the earth in the four positions shown, and they would be about 150,000,000 km from the sun, so the sun's rays are shown parallel. What the figure does show is that on December 22nd, when the North Pole is tilted most away from the sun, the whole of the arctic circle is within the shadow circle, and when on June 21st it is tilted most towards the sun, the arctic circle is wholly in the sunlight. On March 21st and September 21st the shadow circle goes through the poles, the sun is in the zenith at the equator, and day and night are equal in all latitudes. Again we see that in the northern hemisphere December is winter, March spring, June summer and September autumn; while in the southern hemisphere June is winter, September spring, December summer and March autumn. The difference in seasons increases as you

---

[1] Another Greek word for the boundary where the earth and sky (If not interrupted by mountains) appear to meet.

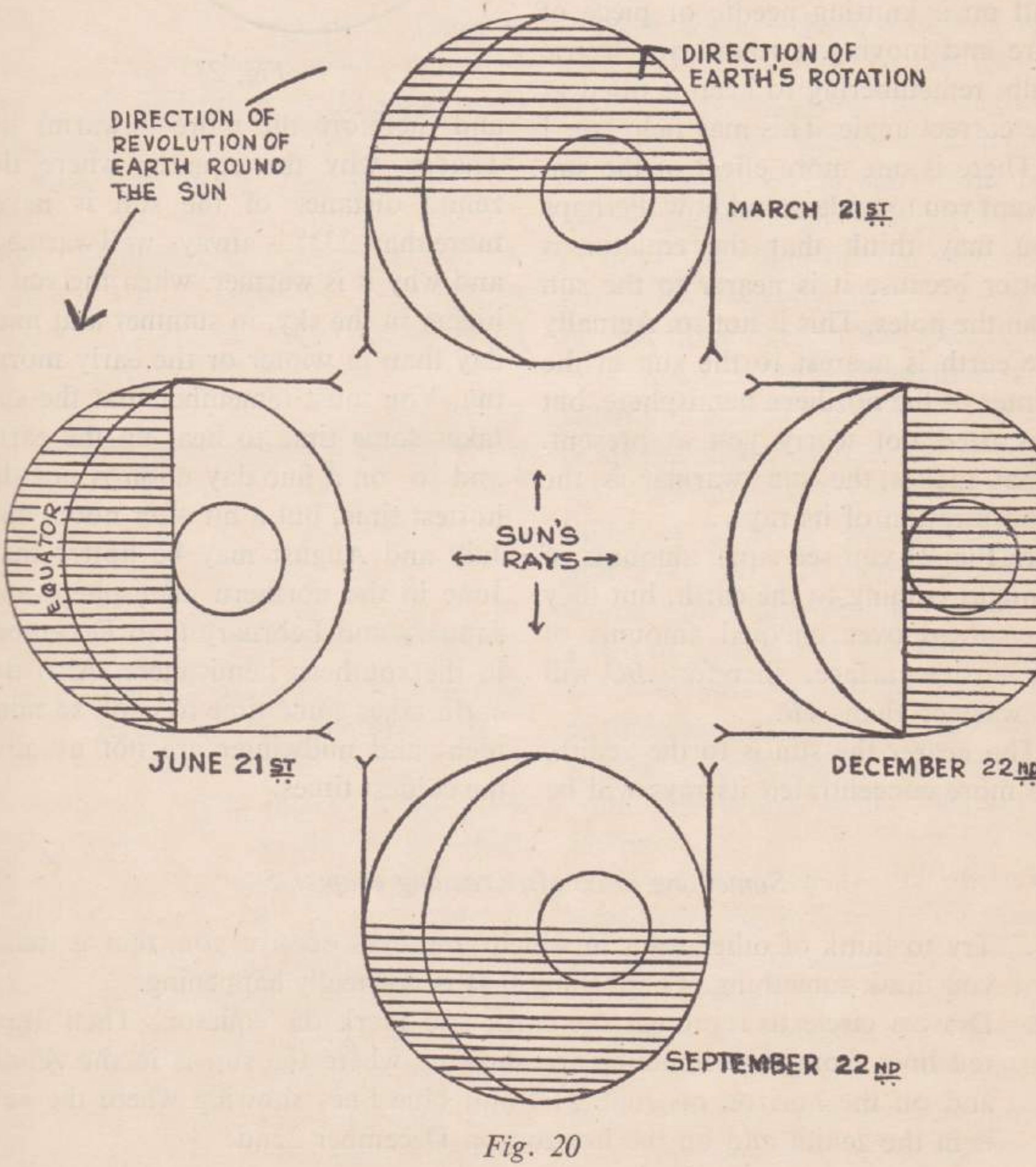

DIRECTION OF EARTH'S ROTATION
DIRECTION OF REVOLUTION OF EARTH ROUND THE SUN
MARCH 21ST
EQUATOR
SUN'S RAYS
JUNE 21ST
DECEMBER 22ND
SEPTEMBER 22ND

Fig. 20

go away from the equator, where the sun is never more than 23½° from the zenith, till at the poles there are six months of light and six months of darkness each year.

All this can be better shown with the help of an orrery, a clockwork model, but very expensive. Try taking your ball on a knitting needle or piece of wire and moving it round an electric bulb, remembering to keep it tilted at the correct angle. This may help you !

There is one more effect of the sun I want you to understand now. Perhaps you may think that the equator is hotter because it is nearer to the sun than the poles. This is not so. Actually the earth is nearest to the sun in the winter of the northern hemisphere, but this need not worry you at present. What makes the sun warmer is the concentration of its rays.

In Fig. 21 you see equal amounts of sunlight coming to the earth, but they are spread over unequal amounts of the earth's surface, therefore *BC* will be warmer than *AB*.

The nearer the sun is to the zenith, the more concentrated its rays will be and therefore the more it warms us. That is why the equator where the zenith distance of the sun is never more than 23½° is always well warmed, and why it is warmer, when the sun is higher in the sky, in summer and midday than in winter or the early morning. You must remember that the sun takes some time to heat up the earth and so on a fine day noon is not the hottest time, but a bit after noon, and July and August may be hotter than June in the northern hemisphere and January and February than December in the southern hemisphere. Also the earth takes some time to cool, so midnight and midwinter are not usually, the coldest times.

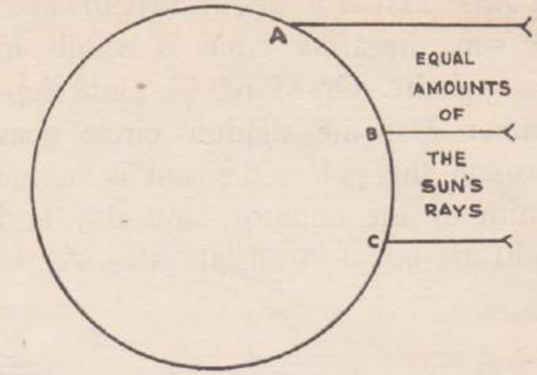


Fig. 21

Something to do after reading chapter 5

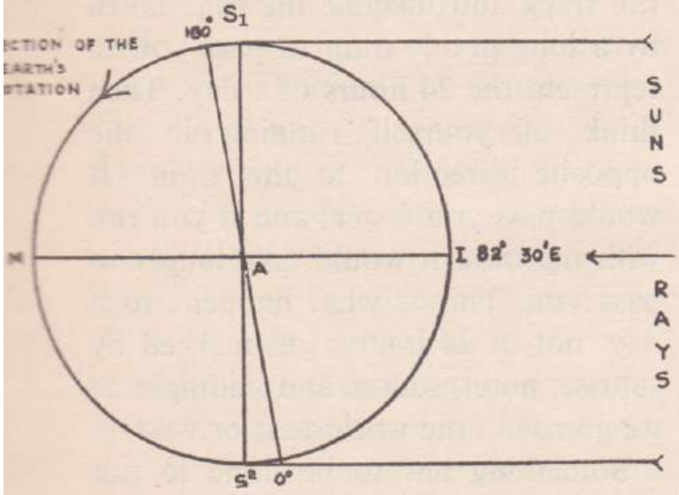
1. Try to think of other ways in which your eyes deceive you, that is make you think something is happening that is not really happening.
2. Draw a circle to represent the earth and mark the equator. Then draw red lines from the circumference showing where the sun is in the zenith and on the horizon on June 21st and blue lines showing where the sun is in the zenith and on the horizon on December 22nd.

6. *Longitude and Time*

The International Date Line

You should remember that as the earth rotates on its axis it turns through 360° of longitude in 24 hours. Therefore, it turns through 15° in one hour and 1° in 4 minutes. There is thus a relationship between time and longitude and this is used to find one's longitude.

Now look at Fig. 22 (below)



Note : A is the North Pole. The circumference is the Equator.

Fig. 22

If the sun is in line with the meridian (*AI* in the figure) from which India takes its Standard Time (IST), that is, 82° 30′ E, then it will be noon along that meridian, and 0630 or 6.30 a.m. by Greenwich Mean Time (GMT), along the meridian marked 0° in the figure. The shadow circle will be along meridian S^1A and AS^2 and it will be midnight along the meridian *MA*.

(Note: a.m. stands for *ante meridiem,* Latin for 'before noon' and p.m. for *post meridiem,* Latin for 'after noon')

Now, if you were in a sputnik whizzing round the world so fast that you could go round in the twinkling of an eye, let us see what would happen. Let us suppose you start from India and fly eastwards on Monday. Starting at noon, the time of that part of the world over which you are flying will be one hour later in the afternoon as you pass each 15° of longitude until, when you cross meridian AS^1, you will enter the shadow circle and when you reach meridian *AM* you come to midnight of Monday between Monday and Tuesday. At meridian AS^2 you would come into daylight again (the dawn of Tuesday ?) and when you get back to India you would be surprised to find them all calling it still Monday; for you must remember you have been round the world in the twinkling of an eye.

If you were to fly the other way, westwards, again starting on Monday at noon, it would get earlier in the morning by an hour for each 15° of longitude you passed, until you reached dawn at meridian AS^2, and went back into night. As you crossed meridian *AM* you would have to call it midnight between Monday and, going backwards in time, Sunday, and when you get back to India you would be calling it Sunday and they would be calling it Monday. Which day would it be: Sunday, Monday or Tuesday ? Of course, it is still Monday and we must find out what has gone wrong with our calculations.

Let us think of it in this way. Suppose you are going round the world in a ship sailing eastwards. Because you are sailing in the opposite direction to which the sun is moving across the sky (for the sun appears to move from east to west, or westwards), the sun will rise one hour earlier for each 15° of longitude you sail, and you will have had one more sunset, midnight and sunrise by the time you get right round the world, than if you had stayed put in the same place. This is what happened to us in the moment we flew round the world eastwards in our sputnik. While the people at home in India were still calling it noon, we passed through a whole day, or what appeared to be a whole day of afternoon, sunset, midnight, sunrise and back to noon, all in the twinkling of an eye.

If, on the other hand, you had sailed in a ship round the world westward you would be sailing in the same direction as the sun's apparent movement across the sky, and for every 15° of longitude you sailed the sun would rise an hour later, and by the time you got right round the world you would have had one less sunrise, midnight and sunset than if you had stayed in the same place.

It is these facts that Jules Verne made use of in his story *Round the World in Eighty Days.* Sailing eastwards the days went faster and we seemed to take one more day to get round the world, while sailing westwards the days lasted longer and we seemed to take one less day to get round. Imagine yourself standing by a rail track and imagine the time taken by a long goods train to pass you to represent the 24 hours of a day. Then think of yourself running in the opposite direction to the train. It would pass you faster; and if you run with the train it would take longer to pass you. This is what happens to a day, not of 24 hours, but marked by sunrise, noon, sunset, and midnight as we go round the world east or west.

Something has to be done to put this right, and what we do is to put the date back one day every time we cross the International Date Line going eastwards, and put it on one day when we cross it going westwards. The International Date Line is roughly down meridian 180° which is convenient, as this meridian goes mostly through the Pacific Ocean. So there are two meridians on the earth where the day changes: one, the meridian where it is midnight, and the other, the International Date Line.

If you look at Fig. 22 again and apply this rule you will see how it works. We start from India flying in our sputnik eastwards and come to meridian AS^1 where it is 6 p.m. on Monday. Then we cross meridian 180° and as we are going east we take off a day and call it Sunday evening, then when we get to the meridian AM where it is midnight we again call it Monday after crossing it and arrive back in India at the same time of the same day as we left, for we have flown in the twinkling of an eye.

Going the other way, westwards, we come to meridian AS^2 where it is Monday 6 a.m.; then we cross meridian AM where it is midnight, and go back into Sunday. Then we come to meridian 180° and as we cross it westwards we put on a day and come into Monday and so back to India.

You will see that that part of the world lying between meridians AM and 180° is calling it Sunday, and it is Monday over the rest of the world.

Days open and close over the world like the petals of a lotus. Let us think what happens, not as we go round the world, but as the world rotates on its axis. If you look at Fig. 22 again you will remember that between longitude 180° westwards to meridian AM where it was midnight, it was still Sunday, while the rest of the world was having Monday. As the earth rotates the meridians on the earth move round with it, but the direction of the sun, and therefore the position of the noon and midnight meridians remain fixed. (This is to neglect the effect of the revolution of the earth round the sun, but you can forget about that for the present.) So gradually Sunday shuts up as 180° moves round to the place where it is midnight, until 180° lies along the midnight meridian and it is Monday all over the earth. Then, as the earth continues to rotate, Tuesday begins to open up between the midnight meridian and 180°. This is explained in Fig. 23 which shows the earth at four different times, six hours apart, the first, six hours after Fig. 22. The part of the world calling it Monday has meridians drawn over it, while that part calling it Tuesday has crosses. The part of the world having night is dotted.

The meridian 82° 30′E from which India takes IST is marked I. You must imagine the sun shining on the right half of the world at an equinox. At 6 p.m. IST on Monday, Tuesday has just begun to open up between the meridian where it is midnight (it would be 172° 30′ E) and the International Date Line (180°).

By the time it is midnight between Monday and Tuesday IST, Tuesday stretches from 82° 30′ E to the International Date Line. By 6 a.m. IST Tuesday has opened further to stretch between 7° 30′ W to 180° and by Tuesday noon IST Monday is closing up and it is Tuesday from 172° 3′ W

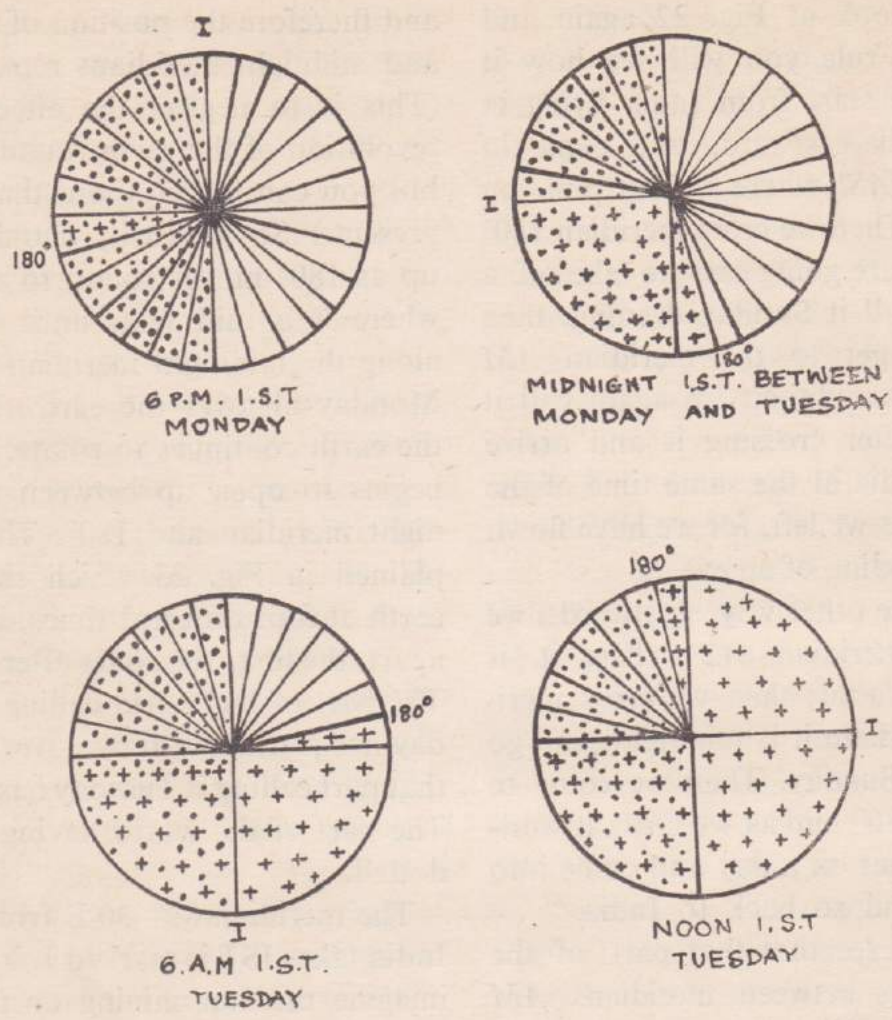


Fig. 23

round past the Greenwich meridian to 180°. Five and a half hours later Tuesday will close and Wednesday will begin to open up round the world.

Now, if you have been thinking and using your imagination, you may have wondered what will happen if the International Date Line goes through the middle of a town. It does not matter much when the midnight meridian passes through a place because most people are asleep and don't bother to think what day it is, whether 0005 of Tuesday or 2355 of Monday. They know when they wake up it will be Tuesday and the day before was Monday. But if a city was divided by the International Date Line and one half was calling it Sunday and having a holiday, while the other half was calling it Monday and supposed to be working, it would be very awkward and confusing. For this reason the Date Line does not run exactly down meridian 180°. Look at it in your atlas and you will see that it juts out eastwards round Asian U.S.S.R., then juts westwards round the Aleutian Islands, and away in the southern hemisphere is again diverted to the east to include various Pacific Islands of the same groups on the same side of the line so that they all call any one day by the same name.

India has a standard time recognised all over the country, the actual time along meridian 82° 30′ E. But the longitude of Port Okha in the west of Gujarat is 69° E, while that of Calcutta is 88° 25′ E. Therefore, there is a difference 19° 25″ of longitude, or very nearly one hour 16 minutes of time, between them. If at an equinox people at these two places get up at dawn, those in Calcutta would be able to stay in bed an hour and a quarter after those in Port Okha were up. But don't all hurry to live in Calcutta, because if you did you would have to go on working for an hour and a quarter after those in Port Okha had stopped.

In India, where the distance from west to east is not so great, it is possible to observe one standard time for the whole country, but the U.S.S.R. is so wide from west to east that the difference in time between western and eastern Russia is eleven hours, and in the U.S.A., not counting Alaska, it is five hours, in Australia three hours. All these countries are, therefore, divided into time belts running north and south though not necessarily exactly down a meridian. For the same reason that the Date Line diverges from 180°, the boundary of a time belt may be moved east or west so as not to run through a city or district.

This was easy enough to deal with in the old, slow-moving world, but with the fast trains and planes of today it makes making up a time-table rather complicated.

I hope you have not found this chapter as difficult to follow and understand as I have found it to write. It does seem a bit complicated till you think it out, but I hope you now understand why you put your watch *on* an hour for every 15° you travel eastwards, and *back* an hour for every 15° you travel westwards; while, to balance this, as you cross the Date Line eastwards you put the date *back* a day and as you cross it westwards you put the date *on* a day.

Something to do after reading chapter 6

Make a world time-clock for yourself. Cut out a circle of stiff paper, or better still cardboard, with a radius of about one inch. Divide the circumference of this into 24 equal lengths of 15° each, and mark the 24 hours of the day at these divisions from 0 to 24 which will be the same as 0. Then cut out another circle of about three inches radius and divide its circumference also into 24 equal lengths of 15° each and mark the meridians 0° to 180° at each division of 15° east and west of the meridian you mark as 0°. Put the names of places, for example, those that you want to listen to on short-wave wireless, along the meridian from which they take their time; for example, England, and France on 0°, Germany 15° E, Moscow 30° E, Melbourne 150°E, and New York 75° W. Remember that India takes its time from meridian 82° 30′ E, so you had better mark this meridian too.

Now take a pin or nail and put it through the centre of both the circles you have cut out, the smaller on top, and stick it into a piece of wood—not into your mother's best table! Holding the larger circle still, or sticking it down to the piece of wood, rotate the inner circle until the correct time is opposite the meridian of Indian Standard Time, and you will be able to read what time it is along all the other meridians you have drawn. Work out for yourself what day it is from 180° and from the position of midnight, 0 or 24 hours.

If you want to know the exact position of the different time zones try to borrow a Time Zone Chart from someone who serves in the Navy or Air Force, or Merchant Navy.

7. *Pressure and Wind Belts*

(A Programmed Lesson with an exercise on Ocean Currents)

I want you to realise that, as well as learning things from a book, there is much that you can think out for yourself by observation and deduction. Indeed this, is the way that man has learned and is still learning. Men have first observed things happening and their results, and then have thought out and tested the laws of cause and effect.

In the first part of this chapter the letter *O* at the beginning of a sentence stands for something that we can all observe, while *D* at the beginning of the next sentence stands for a deduction we can make from that observation. I suggest that you cover up the *D* of each paragraph, think what you would yourself deduce from the *O*, then look at *D* and see if it is what you thought. It is possible you may have made a different deduction than the one given, and be quite right, and if you want to check on this you will have to ask your teacher, but the deduction I give is the one we shall be using later in the chapter.

1. *O*. If we open the valve of an inflated tyre the air rushes out.

D. Air, if free to do so, moves from a region of higher to a region of lower pressure.

2. *O*. The air escaping from the tyre feels cold.

D. Air that is expanding absorbs heat from its surroundings.

3. *O*. When we pump up a tyre the air in the pump gets hot.

D. Air that is being compressed gives off heat (I have had it suggested that the pump gets hot because of friction, but you will find that this is not so if you pump, not into a tyre, but into the surrounding air. There is no great compression and the pump remains cool.)

4. *O*. If a tightly-pumped bicycle tyre is left in the hot sun there is danger of its bursting.

D. Air that is heated expands.

5. *O*. Although it is heavier than air (get someone to empty a bag of it over your head if you don't believe this) soot rises into the air as smoke over a fire.

D. It is carried up by a rising current of air, so heated air expands and becomes less dense (heavy for the same amount) than the surrounding air and floats upwards. This fact is made use of in sending up *gubbaras* and hot-air balloons.

6. *O*. In winter, where it is far enough from the equator for there

to be frost, you will find more hoar-frost (frozen dew) in the hollows, and low-lying ground, than where the ground is level or rising.

D. Cold air settles or sinks down.

7. *O*. In the Himalayas it will often snow on the mountain tops while it rains in the valleys.

D. The higher you go the colder it gets (the rate of cooling in the lower atmosphere[1]—is about 1° centigrade for every 150 metres you go up. This is because the air is not heated noticeably by the rays of the sun as they pass through it, but is heated by the warmth of the earth on which the sun is shining.)

8. *O*. If you jump out of a moving train or bus (it is better not to do so!) you will be carried forward in the direction of its movement unless interfered with by some other force.

D. Once a body is set in motion it tends to keep that motion unless interfered with by some other force. (You will learn about the laws of inertia and momentum in Physics.)

9. *O*. Moisture gathers on the outside of a glass of cold water on a warm day.

D. The moisture must have come from the air as it didn't leak through the glass, so if the temperature of air is lowered condensation of water vapour in it takes place.

10. *O*. In the middle of the day stone sides of a swimming-bath or dry sand beside the sea or a river burn your feet, while the water feels cool. On the other hand, in the early morning the sand and sides of that swimming-bath are cold and the water feels warm.

D. The land heats and cools quicker than water or the sea.

You already know why it is warmer near the equator than away from it (see Fig. 21, Chapter 5), and we will now apply what we have considered above to a study of the world's regular or planetary winds—the winds and changes of pressure caused by the world being a planet rotating and moving round the sun, and to this generalised idea we shall have to add various further effects and their causes.

Stage I

The diagrams in Fig. 24 (next page) show how the heat of the sun in equatorial regions causes rising air (*D*. 4 and 5 above) and low pressure in the lower atmosphere. Winds at the surface blow into this area of low pressure which is known as the Doldrums.

Stage II

The air that has risen over the Doldrums gets cooled but cannot settle straight away as it is being continually pushed up from below. It, therefore, flows outwards away from the Doldrums in the upper atmosphere until it settles, causing high pressure in what

---

[1] From Greek *atmo* meaning vapour or gases and *shpaira* which you know.

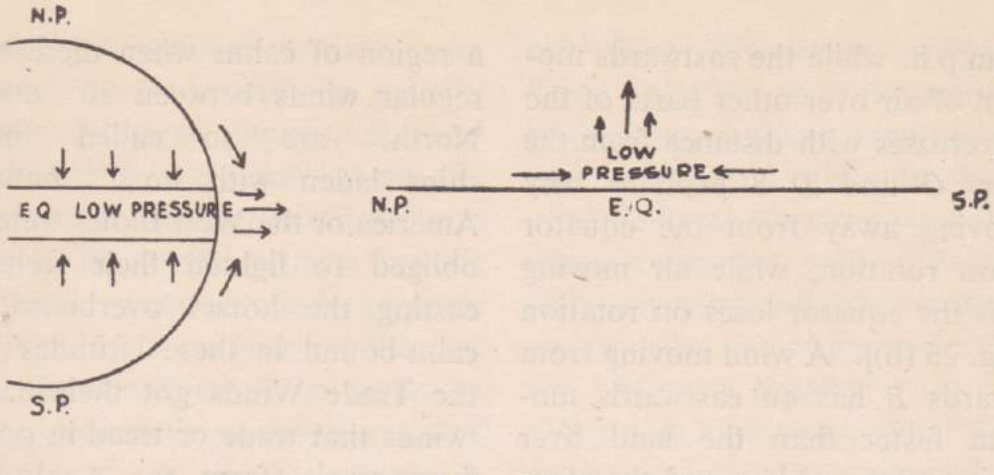


Fig. 24

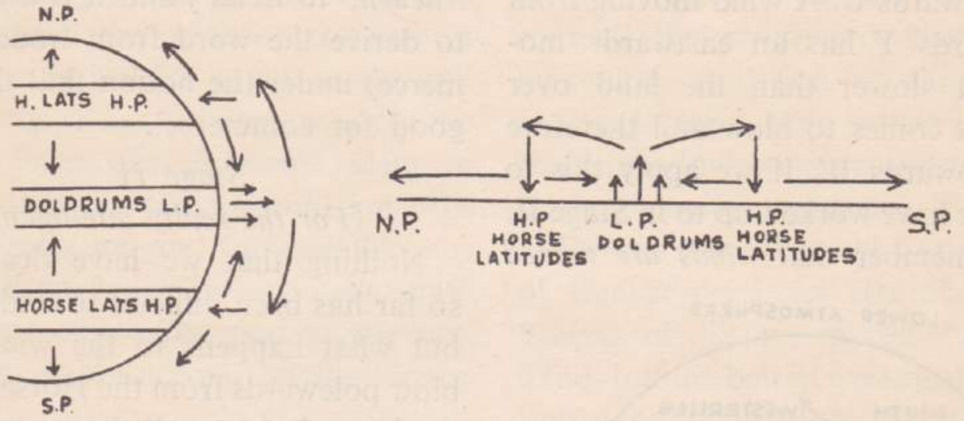


Fig. 25

are known as the Horse Latitudes, From these areas of high pressure surface winds blow (1) towards the Doldrums, (2) outwards—towards the temperate low pressure zones, whose cause will be explained later (see Fig. 25).

Stage III

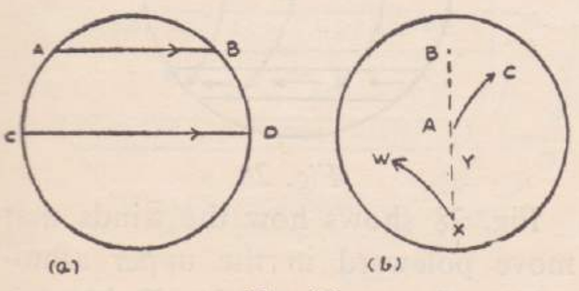


Fig. 26

We now have to consider the effect of the *rotation of the earth* on these winds.

If, in Fig. 26 (a) two men were standing at *A* and *C* they would, by the earth's rotation, reach *B* and *D* in 12 hours. But as *C D* is a longer distance than *AB* the man at *C* will be moving faster (at something over 1500 km per hour). Now, if he were moving through the air at this speed he would not last lone. It follows that the air round the earth is rotating with the earth: that is, air at the equator has an eastwards momentum of some

1500 km.p.h. while the eastwards momentum of air over other parts of the earth decreases with distance from the equator. O and D 8 explains why air moving away from the equator gains on rotation, while air moving towards the equator loses on rotation [see Fig. 26 (b)]. A wind moving from *A* towards *B* has an eastwards momentum faster than the land over which it comes to blow and therefore turns towards *C*. A wind moving from *X* towards *Y* has an eastwards momentum slower than the land over which it comes to blow and therefore turns towards *W*. If we apply this to what we have worked up to in Stage II, and remember that *winds are named by the directions they blow from,* we arrive at this arrangement of the world's regular winds (Fig. 27). According to Brewer's *Dictionary of Phrase and Fable,* the Horse Latitudes, a region of calms when there are no regular winds between 30° and 35° North, are so called 'because ships laden with horses bound to America or the West Indies were often obliged to lighten their freight by casting the horses overboard when calm-bound in these latitudes', while the Trade Winds got their name as 'winds that trade or tread in one uniform track (from the Anglo-Saxon, *traeden,* 'to tread') and it is a mistake to derive the word from trade (commerce) under the notion that they are good for commerce'.

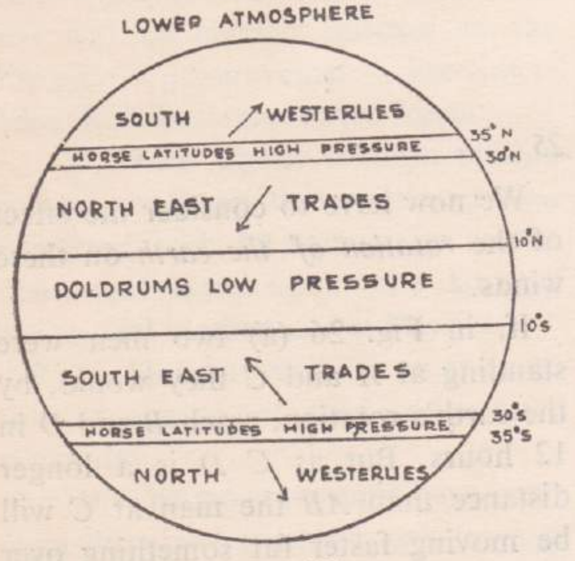


Fig. 27

Stage IV

(*For the really intelligent*)

Nothing that we have dealt with so far has been difficult to understand but what happens to the winds that blow polewards from the Horse Latitudes into what are called temperate low pressure (or sometimes Arctic and Antarctic L.P.) zones is rather more complicated.

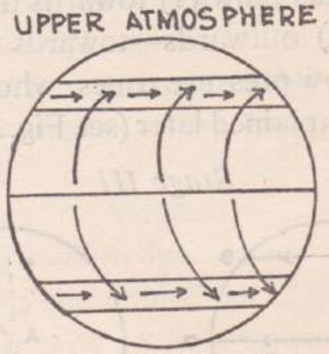


Fig. 28

Fig. 28 shows how the winds that move poleward in the upper atmosphere from above the Doldrums, when their polewards movement comes to an end, continue with an easterly movement due to momentum and form two bands circling round the earth above the Horse Latitudes. From here air sinks to the surface forming the Horse Latitudes high pressure belts. Cold low pressure belts are caused by centrifugal force (compare what happens in the centre of a cup of tea when you stir it) which increases the tendency of the air to be thrown away from the surface (compare a stone being whirled round at the end of a string) as you get towards the poles. From this it would seem to follow that the poles should have the lowest pressure, and for long this was believed to be so by scientists, until explorers discovered that it was not. It is not so on account of the intense cold there which causes a massing of dense air at the poles themselves. The low pressure is thus moved just outside the polar areas, and into these low pressure areas blow the westerlies and winds from the poles. The world's planetary wind circulation is thus completed as in the diagrams in Fig. 29.

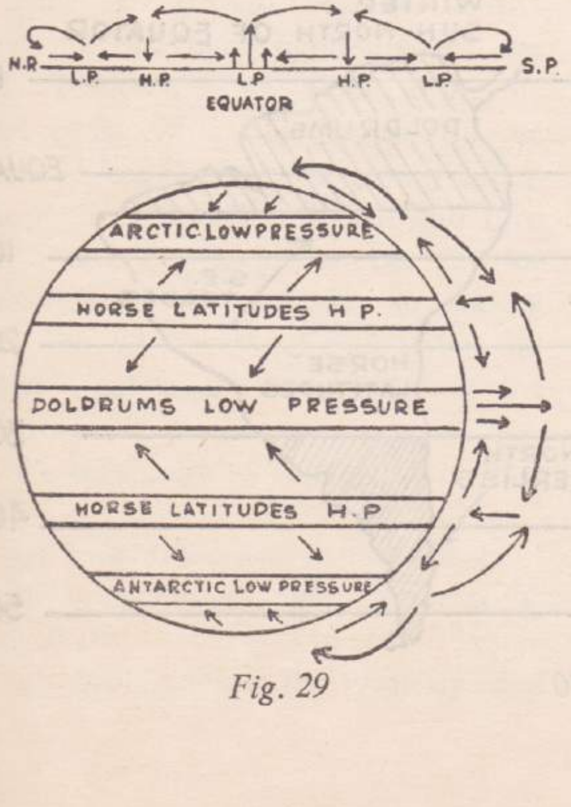


Fig. 29

Stage V

We now have to consider the effect on these winds of the *seasonal shift* of the *sun*, for the position of the sun controls the position of the belt of maximum insolation or exposure to the sun's rays, thus setting up the Doldrums low pressure and being the key to the whole matter.

The sun is in the zenith at the Tropic of Cancer on June 21st and at the Tropic of Capricorn on December 22nd, but the belt of greatest heat does not swing so far north and south since it takes some time for the sun to heat up the earth (compare the facts that a room is not immediately warm as soon as a fire is lit, and that the hottest time of day is not noon but a little after noon). Thus when the sun is in the zenith at Cancer the Doldrums lie roughly between 5 degrees south and 15 degrees north, while by the time the sun has moved over Capricorn, the Doldrums have only moved south to lie between 5 degrees north and 15 degrees south. With the Doldrums swing all the other belts.

We will now consider the effect of this seasonal shift and link it up with *rainfall.*

Reference to *O* and *D* 2, 3, 6 and 9 will explain why:

The Doldrums—expanding, rising, cooling air—are *wet*.

The Trades—air moving to warmer latitudes—tend to be *dry*.

The Horse Latitudes—sinking air coming under greater pressure and getting warmer—are *dry*.

The Westerlies—air moving to cooler latitudes—tend to be *wet*.

These facts are shown on the diagrams of South America for the two seasons below (Fig. 30). The areas we would expect to receive rainfall are shaded. I have taken South America because it is simple to draw and stretches far north and south.

We now have to consider the effect of *relief* on these air currents and the rainfall they cause. Rain caused by a wind having to rise over a mountain range and thus becoming cooler (refer to *O* and *D* 6 and 9) is called *relief rain*. Rain caused by a rising current of warmed air is called *convectional rain*. The Trades tend to be dry as they are moving to warmer latitudes; but if they have to rise over hills the gain of temperature caused by change of latitude is outweighed by the loss of temperature caused by rise in height, and they bring rainfall. The westerlies tend to be wet, but if they have blown over hills and are sinking on the lee side the gain in temperature caused by loss of height and increased pressure is greater than the loss of temperature caused by change of latitude, and they

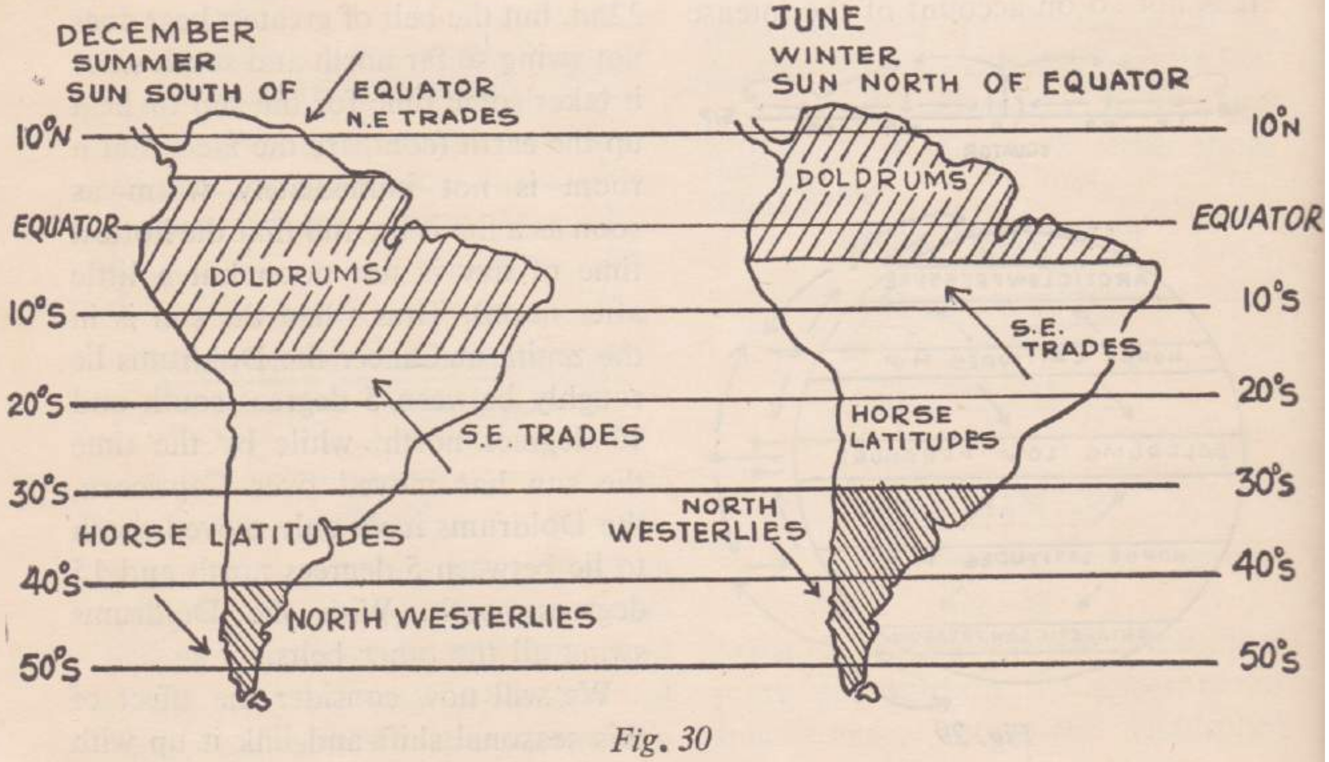
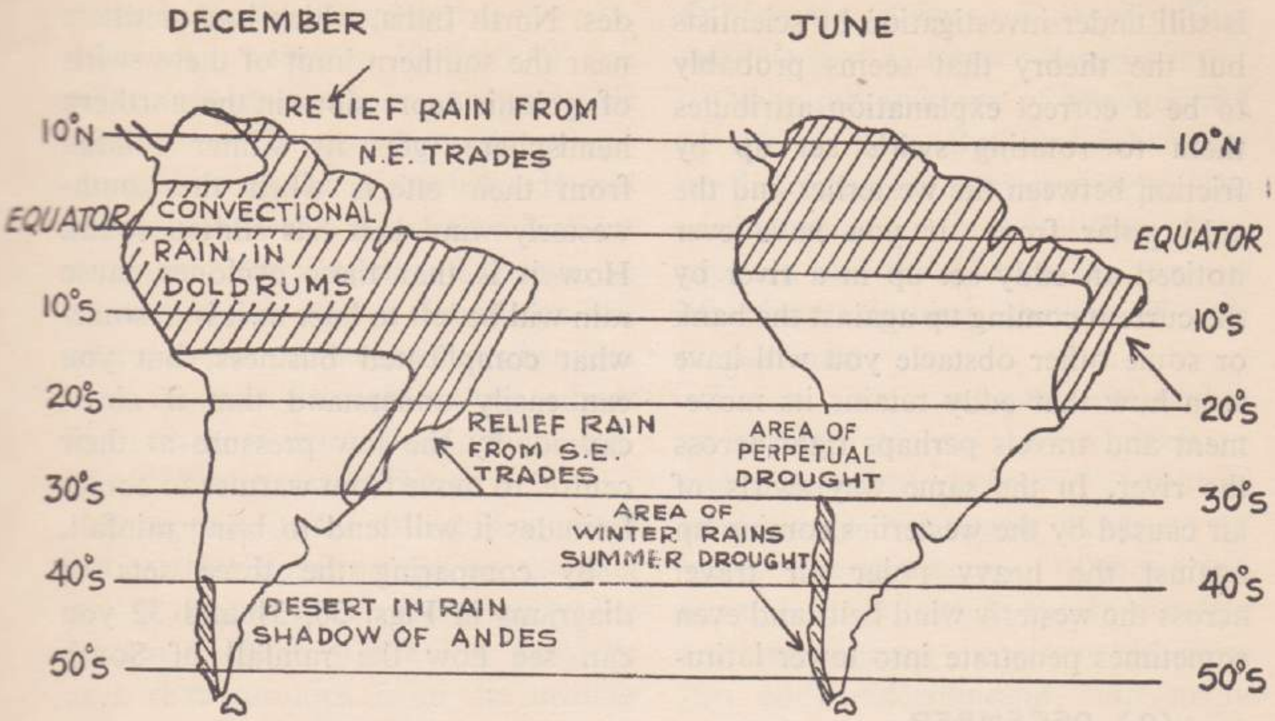


Fig. 30



The effect of relief on rainfall (South America)

Fig. 31

become dry winds.

The next diagram (Fig. 31) shows how the Brazilian Highlands turn the S.E. Trades into wet winds along the east coast, while the Andes rob the North-Westerlies of their rain along the west of South America, and turn them into dry winds on the east or leeward side of the Andes so causing the shingle desert of Patagonia, in, what is called, the rain shadow of the Andes.

We now have to consider the effect of :

(a) The difference in the effects of heating *land* and *water* (Refer to *O* and *D* 10).

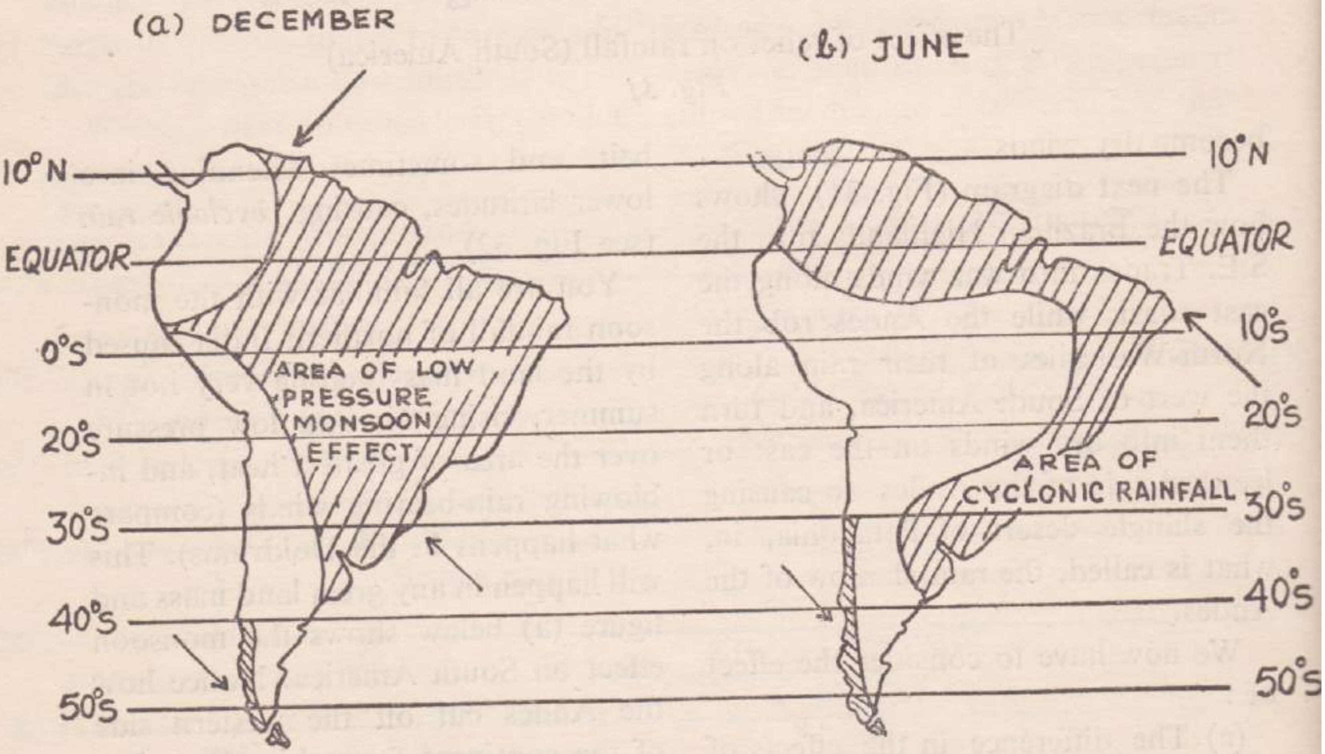
(b) *Depressions* in the Westerly wind belt, and sometimes extending into lower latitudes, causing *cyclonic rain* (see Fig. 32).

You are all familiar with the monsoon rainfall of northern India caused by the land mass getting very hot in summer, rising air and low pressure over the area of greatest heat, and inblowing rain-bearing winds (compare what happens in the Doldrums). This will happen in any great land mass and figure (a) below shows the monsoon effect on South America. Notice how the Andes cut off the western side of the continent from this effect, just as the Himalayas retain the Indian Monsoon.

The cause of cyclonic depressions

is still under investigation by scientists but the theory that seems probably to be a correct explanation attributes them to rotating swirls set up by friction between the westerlies and the cold polar front. If you have ever noticed an eddy set up in a river by the current coming up against the bank or some other obstacle you will have seen how that eddy retains its movement and travels perhaps right across the river. In the same way swirls of air caused by the westerlies coming up against the heavy polar air travel across the westerly wind belts and even sometimes penetrate into lower latitudes. North India, which is somewhere near the southern limit of these swirls of cyclonic depressions in the northern hemisphere, gets its winter rainfall from their effects when the south-westerly wind belt has shifted south. How it is that these cyclones cause rain will be left to later as it is a somewhat complicated business, but you can easily understand that if air is caused, by the low pressure at their centre, to move from warmer to cooler latitudes it will tend to bring rainfall.

By comparing the three sets of diagrams in Figs. 30, 31 and 32 you can see how the rainfall of South



(a) Rainfall caused by summer low pressure
(b) Rainfall caused by winter cyclonic depressions.

Fig. 32

America has been analysed.

Between latitudes 30 and 40 you will notice the area on the west that receives winter rain from the northward shift of the westerlies. It will have a mild wet winter and a hot dry summer. Such a climate is known as *Mediterranean* and is found on the western sides of all continents between these latitudes (though in the northern hemisphere it is caused by the southerly shift of the westerlies).

Between latitudes 20 and 30 you will notice the extensive area on the east whose summer rain is increased by the monsoon effect of the low pressure area that develops from the heating of the land. Such a climate is known as *China type*.

In higher latitudes on the east is an area that receives winter rain from cyclonic depressions. Such a climate is known as *temperate east coast climate*.

The positions of *sub-tropical deserts* correspond with that of the Atacama Desert in all continents (compare the Californian, Sahara, Kalahari, Thar and Western Australian deserts).

Other sub-divisions of climates will be left for later. But remember that on the climate of a place depends the vegetation and animal life that it can support, and thus the natural way of life (food, clothing, shelter) of man in that area.

I want you to take this chapter as an example of one way in which to tackle learning. Learning is not a matter only of mugging things up by heart. A certain amount of that grind has to be done, but the result is lifeless and meaningless unless to learning you add understanding; and many problems can be worked out by thinking and building up, rather than by having the solution in your head. I have tried, in this somewhat over-long chapter, to show you the method of thinking and building up as I apply it to the world's geography. Try to apply the same methods yourselves in all suitable subjects.

Something to do after reading chapter 7

Look in your atlas and find a map of the world showing ocean currents. Though there are other causes which set up currents in the ocean and which you can learn about later, the most important is the direction of the prevailing winds which cause the water at the surface to drift in the direction the wind is blowing. You would, therefore, expect to find currents moving towards the east in the westerly wind belts, and towards the west in the trade wind belts (remember that a wind is named by the direction it blows from). When such a current comes up against a mass of land, part of it will be deflected northwards and part southwards. If you look in your atlas at the North Equatorial Current set up by the N.E. Trade Winds in the Pacific Ocean, you will see that when it reaches Asia part of it is turned southwards, and recrosses the Pacific as the Equatorial Counter-Current, while part is turned northwards as the Kuro Siwo (meaning 'blue salt') which then recrosses the north Pacific under the influence of the south westerly winds as the Kuro Siwo Drift or North Pacific Current. In the north Atlantic the North Equatorial Current turns northwards as the Gulf Stream and recrosses the Atlantic in the south westerly wind belt as the Gulf Stream Drift or North Atlantic Current. When the Gulf Stream Drift reaches the coast of Europe it too divides north and south, becoming the Labrador Current and the Canaries Current; while the Kuro Siwo or North Pacific Current divides into the Alaska and Californian Currents.

In the southern oceans there is a similar arrangement, except that in the Indian Ocean the South West Monsoon winds have their effect. In the South Pacific the South Equatorial Current turns southwards as the East Australia Current and then, under the influence of the north westerly winds, recrosses the ocean as the West Wind Drift (or South Pacific Current) till part of it is turned northwards by South America to become the Peru Current; while in the South Atlantic part of the South Equatorial Current is turned southwards as the Brazil Current, recrosses the Atlantic under the influence of the north westerly winds, and is partly turned northwards by the west coast of Africa as the Benguela Current.

Now one important thing about these currents is their effect on the temperature of the winds that blow over them. A current drifting away from the equator will, like a wind blowing away from the equator, be relatively warm; while a current drifting towards the equator will be a cool current. Thus the winds from over the Gulf Stream and Gulf Stream Drift (or North Atlantic Current) cause the relatively mild winters of N.W. Europe. Plants from tropical regions can be grown in the open in north west Scotland that would be killed by the cold of Labrador in the same latitudes.

Another example of an effect of these currents is the fogs in the Atlantic which are so dangerous for ships off Newfoundland. These are caused by the warm air over the Gulf Stream meeting the cold air over the Labrador Current. The water vapour in the air over the Gulf Stream condenses to form the tiny drops which make clouds and fog, and which makes it difficult for sailors to see icebergs drifting down in the Labrador Current.

Now, with the help of your atlas, make a list of (*a*) the warm currents and (*b*) the cool currents in the Pacific and Atlantic Oceans.

(*Note*. The terms 'warm' and 'cool' are used in relation to the temperatures of the latitudes into which currents flow.)

8. The Measurement of Latitude and Longitude on the Earth's Surface

(A Programmed Lesson)

I suggest that you read this chapter in two parts. First up to question 27 dealing with latitude, and then the rest dealing with longitude.

You know that the latitude of any place depends on the angle at the centre of the earth subtended. First, I will explain that word. It is from the Latin and means 'stretched under', and you have used the Greek word hypotenuse which means the same thing, but is used for the side of a triangle opposite a right angle. Well, the latitude of a place depends on the angle at the centre of the earth subtended by the distance north and south between the equator and the place whose latitude you want to find. Look at Fig. 33 and we will do a little revision. You will find the answers to each question at the end of the chapter. Look up each one after you have given your answer.

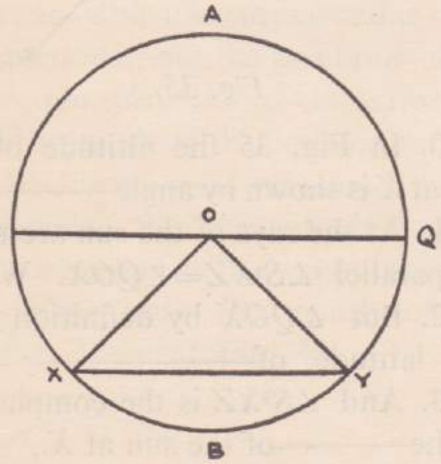


Fig. 33

1. If EQ is the equator A and B will be the ————————and———.

2. If we draw a line from A to B it would represent the earth's———.

3. The latitude of A and B is—and——————.

4. And if $\angle QOY$ is 45°, the latitude of XY is——————.

Now there are two common ways of finding one's latitude. One is roughly from the Pole Star (Dhruva in Hindi) for places in the northern hemisphere; (if you can get hold of

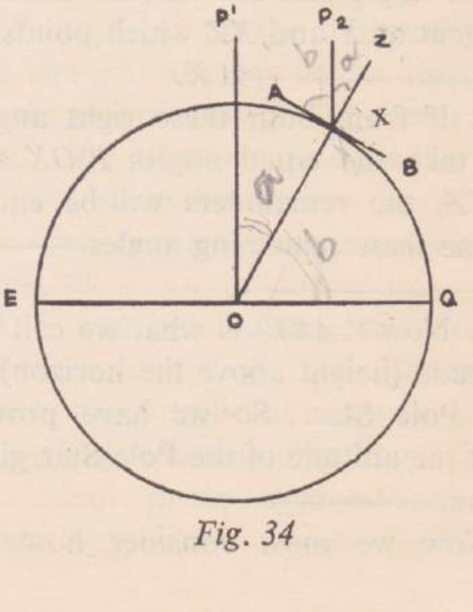


Fig. 34

Thor Heyerdahl's *The Ra Voyages* do read it, and in it you will find, as well as the story of many exciting and amusing adventures, such as making boats of reeds and then sailing them across the Atlantic, his description of how he made a simple instrument to find his latitude from the Pole Star). The other method is from the sun at noon. Look at Fig. 34.

5. Suppose you want the latitude of X. By definition it is given by angle ________.

6. The Pole Star is much farther away from the earth than the sun, so its rays can be taken to be parallel by the time they reach the earth and OP_1 and XP_2 pointing to the Pole Star are parallel. Name the corresponding angles that will be equal ________ and ________.

7. Now $\angle P^1OQ$ between the earth's axis and the plane of the equator is 90°, and $\angle AXZ$ is also 90° because it is the angle between AB, the horizon tangent at X and XZ which points to the ________ at X.

8. If from both these right angles we take the equal angles P^1OX and P^2XZ, the remainders will be equal. Name these remaining angles ________ and ________.

9. Now $\angle AXP^2$ is what we call the altitude (height above the horizon) of the Pole Star. So we have proved that the altitude of the Pole Star gives us our ________.

Now we must consider how we measure latitude from the sun. This is straightforward if the sun is in the zenith at the equator, for the complement (that which is added to it to make up 90°) of the angle of altitude of the sun (what we have learned is called the zenith distance of the sun) at noon, gives the latitude of the place where the angle is measured.

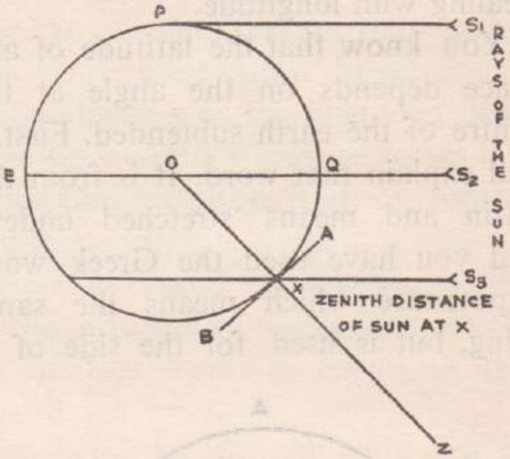


Fig. 35

10. In Fig. 35 the altitude of the sun at X is shown by angle ________.

11. As the rays of the sun are taken as parallel $\angle S^3XZ = \angle QOX$. Why ?

12. But $\angle QOX$ by definition gives the latitude of ________.

13. And $\angle S^3XZ$ is the complement of the ________ of the sun at X.

14. The complement of the altitude of the sun is the same as its ________ distance.

15. From the figure you can also see that the altitude of the sun at Q is ________°.

16. And the complement of 90° is 0° and this is the latitude of the ________.

17. And the zenith distance of the sun at Q is——————.

18. While the altitude of the sun at P is——————.

19. And the complement of 0° is 90,° and this the latitude of the———.

20. And the zenith distance of the sun at the Pole is———.

21. We must remember that the complement of the angle of elevation of the sun (its zenith distance) at noon only gives us a latitude when the sun is in the zenith at the———.

22. This is only at an———.

If we want to find a latitude from the zenith distance of the sun at noon at any other time of the year, when the sun will be either north or south of the equator, we have to find out from an almanac (a calendar with information about the positions of the sun, moon, planets and stars) how far north or south of the equator the sun is. This distance is measured as an angle called the angle of declination of the sun, and is the angle the sun's rays make with the zenith of the equator. Look at Fig. 36.

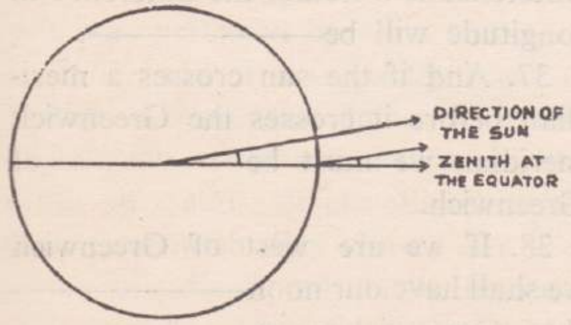


Fig. 36

This shows that if the declination of the sun is X°N it will be in the zenith at X°N.

Having looked up in an almanac the declination of the sun for the day we want, we have to decide whether its elevation, where we are, would, at the equinox, be more or less. Then we subtract the angle of elevation that it would have been from 90° to find our latitude.

23. For example, if the sun is 10° N of the equator and we are where it is in the zenith, its elevation at the equinox would have been 10° less, the zenith distance of the sun would not have been 0°, but——————.

24. And that will be our———.

One way to calculate latitude from the sun is (*i*) To find the noon elevation of the sun. You know how to do this from the shadow of a pole, but it is normally measured with an instrument called a sextant. Let us suppose we have found it to be 80° 30′.

(*ii*) To look up the declination of the sun on that day in an almanac. Let us suppose it is 21° 30′ south.

(*iii*) We then say to ourselves 21° 30′ S is where the sun is in the zenith. For each degree we move away from there, the sun's altitude will decrease by 1°, and we calculate how far we have to move from 21° 30′ south, where the altitude of the sun is 90° in order to reduce its altitude to 82° 30′.

25. How many degrees shall we have to go ?——————

26. Now, we might go northwards, and this would bring us to latitude 21° 30′ minus 7° 30′ or 14° S, or we might go southwards, which would bring us to what latitude ?——————
In order to know in which of these latitudes we were, we would only have to observe whether the sun was south of us or north of us.

27. In which latitude would we be if the sun was south of us ?——————

Having shown how we can measure latitude without having to go to the centre of the earth to do so, let us now consider how longitude is found, starting with a bit of revision.

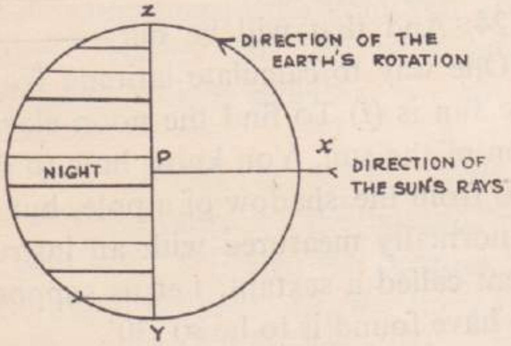

z
DIRECTION OF THE EARTH'S ROTATION
P
x
DIRECTION OF THE SUN'S RAYS
NIGHT
Y

Fig. 37

28. Look at Fig. 37. If P is the North Pole and the circle the equator, you will see that all places on meridian *PX* are having their noon, while places on *PY* are having sunrise and at places on *PZ* the sun is——————.

29. Although the lines *PY*, *PX*, *PZ* are going in different directions in the flat figure, because the earth is spherical, if they were drawn on a globe, they would all meet on the other side at the—————— ——————.

30. They are, therefore, all North-South lines or meridians and *PZ* has had its noon——————hours before.

31. And *PY* will have its noon six hours——————than *PX*.

32. The longitude of a place is named according to the angle the meridian passing through it makes at the Pole with the Prime Meridian, which is called 0° and is usually taken as the meridian passing through the observatory at——————.

33. If *PX* is the Prime Meridian, then *PZ* will be called 90° E and *PY* will be called——————.

34. It is easy to calculate that, as the world rotates through 360° in 24 hours, in one hour it will turn through ——————degrees.

35. Thus a difference of 1° of longitude means a difference of—————— minutes of time.

36. So, to calculate the longitude of a place we have to know the difference in the times that the sun crosses the meridian of Greenwich and the meridian of that place. If the difference is 3 hours, the difference in longitude will be——————.

37. And if the sun crosses a meridian before it crosses the Greenwich meridian we must be——————of Greenwich.

38. If we are west of Greenwich we shall have our noon—————— than Greenwich noon.

39. We find this difference in time

by observing exactly when the sun crosses our meridian, and at that time observing exactly what the time is at——————.

40. To find when the sun crosses our meridian an accurate way is to use a sextant, which you may learn about later. A rough-and-ready way is to note when the shadow of a pole is shortest, or when the shadow lies along the North-South line from the pole, for then the sun will be crossing our meridian. If the sun is shining and the pole throws no shadow, then the sun must be in the zenith or directly——————.

41. But the sun will never be in the zenith if where we are, lies outside the——————.

42. To observe what the time is at Greenwich we must have a watch that keeps exact Greenwich time (or we could set a watch to Greenwich time from a radio time signal). A pendulum clock would be upset at sea or when moved about. It was not until very accurate spring clocks or watches had been invented that man could accurately calculate longitude. This invention was perfected by John Harrison in 1761, and it was partly because British sailors were doing so much exploration of the world in the eighteenth and early nineteenth centuries that Greenwich was chosen for the prime meridian, and partly because 180° makes a convenient Date Line. A very accurate watch or clock is called a chronometer, a word derived from the Greek *metron*, 'measure', and *khronos* which, if you don't know, you can easily guess is the Greek for ——————.

43. Let us suppose that when the sun crosses our meridian it is 0730 GMT (Greenwich Mean Time). As our time is 1200 the difference in time is————hours————minutes.

44. So our Longitude will be———

Note : ′is a sign for minutes.
″is a sign for seconds of either time or angle.

45. When we are calculating these differences we must be careful not to mix up minutes and seconds of angles with minutes and seconds of time. As we have already worked out, 1 degree of longitude makes a difference of 4 minutes of time, so half a degree, or 30′ of longitude, makes a difference of————minutes of time.

46. And a difference of one minute of time makes a difference in longitude of an angle of——————.

The easiest way to avoid muddle is to make a table like this

Table I		*Table II*	
Time	Angle	Angle	Time
1 hour	15°	1°	4 minutes
1′	15′	1′	4 seconds
1″	15″	1″	1/15 second

47. Suppose we were at sea and found that when it was our noon, GMT was 13 hrs. 24′, 30″, the difference in time is——————.

48. As we have our noon after Greenwich, we are——of Greenwich.

49. Using the first table above, we write down for one hour an angle of 15°; and for 24′ of time we write down an angle of 15′ × 24, which is—— degrees.

50. And for 30″ of time we write down an angle of 15″ × 30, which is——′ ——″ of angle.

51. So our longitude is —°—′—″ W.

52. Now let us try the calculation the other way round. The longitude of Ajmer is 74° 38′ 30″ E. We will work out the difference between its *local* time (*Not* IST—Indian Standard Time) and that of Greenwich, and we will use the second table above. (You will remember that local time is the time of a place taken from when the sun crosses its meridian, and may be different from the time of the country or time belt in which it lies.) 74° will equal——minutes of time.

53. This makes —— hours and—— minutes.

54. 38′ of angle is —— seconds of time.

55. This makes —— minutes and ——seconds.

56. 30″ of angle is—— seconds of time.

57. Therefore our total difference in time will be——″.

We can check this answer if you like playing with figures. If you do not or are tired you can leave out the rest of the questions in this chapter.

We have found that the difference between Ajmer local time (that is, when the sun crosses its meridian is its noon) and GMT is 4 hours 58′ 34″. We know that the difference between IST and GMT is 5 hours 30′.

58. Therefore the difference between IST and Ajmer local time is——′ ——″ of time. (Don't forget when subtracting that a minute is 60″ so 2′ less 1′ 40″=20″).

59. 31 minutes of time is——′ of angle.

60. Which is——° ——′ of angle.

61. And 26″ of time is——″ of angle.

62. Which is——″ ——″ of angle.

63. Therefore, the difference in longitude between the Ajmer meridian and the meridian from which IST time is taken is——° ——″

Add this to the longitude of Ajmer (74° 38′ 30″) and you get 82° 30′ so, our calculations have worked out correct.

Answers to the questions in chapter 8

1. North and South Poles

2. Axis

3. 90° N and 90° S.

4. 45° South

5. *ZOQ* or *QOX*.

In future I shall only name an

angle in one of the two ways possible.
6. P^1OX and P^2XZ
7. Zenith
8. ZOQ and AXP^2
9. Latitude
10. AXS^3
11. Corresponding angles
12. X
13. Altitude
14. Zenith
15. 90°
16. Equator
17. 0°
18. 0°
19. Pole or Poles
20. 90°
21. Equator
22. Equinox
23. 10°
24. Latitude
25. 7° 30′
26. 29° S
27. 14° S
28. Setting (or on the horizon)
29. South Pole
30. Six
31. Later
32. Greenwich
33. 90° W
34. 15
35. 4
36. 45°
37. East
38. Later
39. Greenwich
40. Overhead (or above us)
41. Tropics
42. Time
43. 4 hours 30 minutes
44. 67° 30° East
45. 2
46. 15′
47. 1 hour 24′ 30″
48. West
49. 6°
50. 7′ 30″
51. 21° 7′ 30″ W.
52. 296
53. 4 hours 56 minutes
54. 152
55. 2 minutes 32 seconds
56. 2
57. 4 hours 58′ 34″
58. 31′ 26″ of time
59. 465
60. 7° 45′
61. 390
62. 6′ 30″
63. 7° 51′ 30″

Something to do after reading chapter 8

I hope you still have the pole you should have put upright in a level place after reading chapter 2, and that you have been making observations of its shadow at different times of the day, and at noon at different times of the year. If the pole is still in position use it, if not put up another and find its latitude and longitude. You will have, as I hope you now realise, to observe two things at noon when the pole's shadow points N and S and is shortest, or it has no shadow: first, the zenith distance of the sun, and second, GMT. Set your watch at GMT from a time signal, or take 5½ hours from IST and note the difference in time between noon by your pole and noon GMT by your watch and work out your longitude.

For latitude you find the sun's zenith distance, but will also need to know its declination. If you can, look this up in an almanac. If you can't get an almanac, you can calculate its declination very roughly as follows. You know the sun moves or appears to move through some 94° of latitude in about 365 days (if you start in December, from the Tropic of Capricorn to the Tropic of Cancer in June and back to Capricorn by next December) therefore, on average it moves about 1° north or south in a little less than four days. If you take the nearest date on which you know the position of the sun—a solstice or equinox—and compare it with the date on which you make your observation you can work out roughly the declination of the sun. For example, if your observation was made on April 3rd you would know that on March 21st the sun was in the zenith over the equator and that since then it has moved northwards for 13 days and it would therefore have a declination of something more than 3°N. This is very rough-and-ready but good enough perhaps for the sort of measurements one can make with a pole. In actual fact, as you can see if you have an almanac, the declination of the sun does not alter at a regular rate. It takes about 10 days to move 1° at the solstices and less than 3 days at the equinoxes. So if you ever become a navigator at sea or in the air you will have to learn that the apparent movements of the sun are more complicated than I have described. I am only trying to give you the general idea. As a navigator or astronomer (Greek again, meaning 'star arranger') you would have to be much more accurate than you can be with our rough-and-ready methods. Otherwise you might be, what some rude people call a navigating officer in the navy, 'the wrecker'.

9. Something about Weather

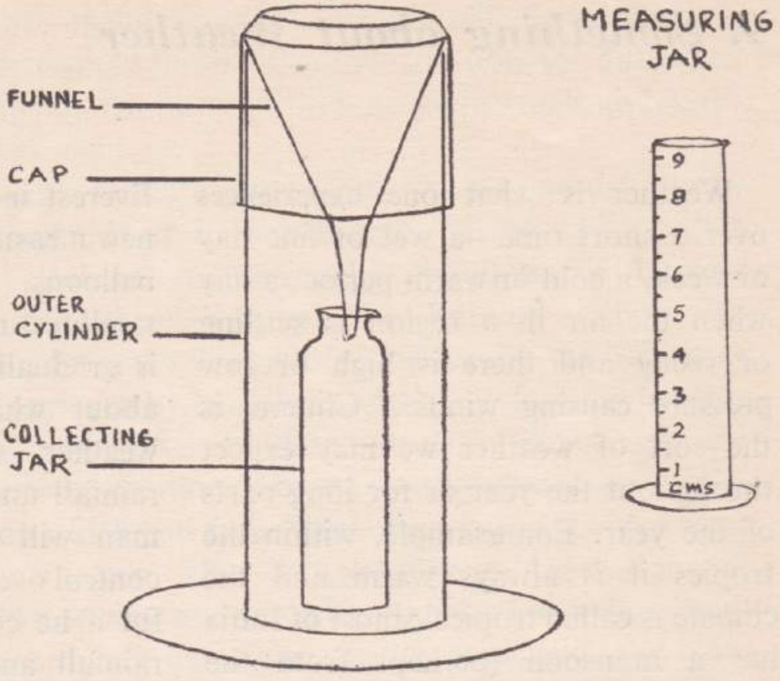
Weather is what one experiences over a short time—a wet or fine day or week, a cold or warm period, a day when the air in a region is settling or rising and there is high or low pressure causing winds. Climate is the sort of weather we may expect throughout the year or for long parts of the year. For example, within the tropics it is always warm and the climate is called tropical; most of India has a monsoon (perhaps from the Arabic *mausim* meaning 'season') climate, with dry winters and rains in the summer. It is possible to distinguish between a number of different climates, but first we will consider the weather which adds up to make climate.

A study of weather is known as meteorology, another word derived from Greek meaning roughly 'a study of changes that go on in the skies or atmosphere'. For India this is carried out by the Indian Meteorological Service, a fine body of scientists, who are responsible for the daily weather reports that used to be published in the papers. Recording the weather is easy enough, but to foretell or forecast what it is going to be is much more difficult and the forecasts of the meteorological service are not always correct. However, they were of great assistance to the Indian Expedition that climbed Everest in 1964, and man by making new measurements of the weather from balloons, rockets and man-made satellites revolving round the earth, is gradually learning more and more about what causes changes in the weather, storms and droughts and rainfall and so on. Perhaps one day man will be able to exercise some control over the weather; how wonderful if he could give all India enough rainfall and prevent the excess that causes floods!

The chief things that make up the weather are temperature, rainfall, changes in the pressure of the atmosphere causing winds, and humidity or the amount of water vapour in the atmosphere (see Chapter 7). The usual instruments with which we measure these things are :

(1) for temperature, a thermometer. This comes from the Greek words for 'heat measure'. You have all heard of a thermos flask which keeps the heat in or out. Mostly thermometers are thin air-free sealed tubes with mercury in a bulb at one end. The mercury expands with heat and a column, from which you can read the temperature, is pushed by the expansion up the tube, or falls when the temperature goes lower. As you can't be looking at the temperature all the

time, weather recorders usually use two thermometers, one to show the highest or maximum temperature and the other the lowest or minimum temperature recorded since the thermometers were last looked at. One form of maximum thermometer is filled with mercury whose surface is convex (curved like the outside of part of a circle) and a little metal indicator is put in the tube outside the mercury. Now liquids have a surface tension, a sort of elastic covering—and if you are careful you can float a needle on water because of this and water beetles can walk on water—and the surface tension of the mercury pushes the indicator up and leaves it at the highest point to which it rises. The minimum thermometer is filled with alcohol which has a concave (curved like the inside of part of a circle) surface. The indicator is put inside the alcohol and is pushed down to the lowest temperature to which the alcohol falls. When resetting the thermometers the indicators are moved back to the surface of the liquid with a magnet.



Rain Gauge
Fig. 38

(2) For rainfall, a rain gauge (see Fig. 38). This is a funnel (what is used for pouring liquid or powder into a bottle) fitted into a container so that any rain that falls into the mouth of the funnel goes into the container and does not evaporate. When you want to measure how much rain has fallen, you pour the rain water from the container into a measuring glass. This is done to make it easy to measure a small quantity. The measuring glass is thin and tall and measurements on it are marked according to the difference between the areas of the mouths of the funnel and the glass.

(3) The pressure of the atmosphere is measured by a barometer (Greek, *baros*, 'weight'). The weight of the atmosphere is stated in bars and millibars and one bar or 1,000 millibars is equivalent to 750·1 millimeters (24·53 inches) of mercury at sea level at 0°C in latitude 45°, and the pressure

of the atmosphere will force a column of mercury to around this height up a glass tube closed at the top end, with its open end at the bottom put into a bowl of mercury on which the atmosphere exerts its pressure. Before the mercury is let into the tube, the tube has to have all the air in it removed. You can ask your science teacher to explain these instruments more fully if you don't understand. When the pressure of the atmosphere is low the mercury in the tube of the barometer falls, and when it is high the mercury rises. Pressure can be expressed either in millibars or as the length of the column of mercury.

(4) The direction and speed of the wind is measured by an instrument called an anemometer, or the direction alone by a weather-cock or wind vane. You must have seen a weather-cock on a roof somewhere. An anemometer is often made of a system of cups which are blown round by any wind there is, and the speed or force of the wind is recorded from the speed at which the cups are blown round.

(5) The amount of water vapour in the atmosphere is measured by, what are called, wet and dry bulb thermometers. If you blow on the back of your hand your breath feels warm, but if you lick the back of your hand and blow on it till it is nearly dry, it will feel cool. It is not the temperature of your breath that has altered, but the cool feeling is caused by the evaporation of your lick, the turning of the liquid back into the gas called water vapour. The Mogul emperors used to have ice made by the cooling caused by evaporation. On nights when it was cold, but not cold enough to turn much water into ice, they would have a little water put into earthenware saucers from which evaporation could easily take place, and these were left in the open air. In the morning thin sheets of ice could be collected from the saucers and this was stored underground for use in the hot weather.

A wet bulb thermometer has a wick of cotton dipping into a small bowl of water and the wick is wrapped round the bulb of the thermometer. As evaporation from the wick takes place the temperature is lowered and from the difference between the temperature shown by the wet bulb thermometer and that shown by the dry bulb thermometer, the percentage of water vapour in the air, known as humidity (from the Latin for 'moisture'), can be calculated. If the wet bulb temperature is much lower than that shown by the dry bulb there is a lot of evaporation and the air is dry. If both thermometers show the same temperature there is no evaporation, and the air is said to be saturated (from the Latin for 'full') and humidity is 100 %. There are tables to show the relative humidity at different readings of the wet and dry bulb thermometers.

If records of these readings of the

weather are kept throughout the year and plotted as graphs then the graphs will tell you what sort of climate a place has (see Chapter 10).

If we want to see what sort of weather India has had on any one day we can draw charts showing the temperature, pressure, wind direction and rainfall for that day, and this is done by the Indian Meteorological Service under the Director-General of Observatories; or we could make such charts showing the average of the weather for any month. On such charts temperature is shown by lines called isotherms (Greek for lines of 'equal temperature'). All places on the same isotherm have the same temperature. Pressure is shown by isobars (lines of equal pressure) and all places on the same isobar have the same atmospheric pressure. Before drawing the isotherms and isobars the temperature and pressure of all places are reduced to what they would have been at sea level; otherwise the map would show more of the effect of local changes of altitude than widespread changes of temperature and pressure. You already know that the higher you go the colder it gets (see Chapter 7) and it is obvious that the less air there is above you the less it will weigh. The pressure of the atmosphere decreases about 1 cm mercury or 13·3 millibars for every 100 metres you go up from sea level, and faster, the further you go up.

Temperatures are taken in the shade as we want to know the temperature of the air rather than how hot the rays of the sun would make the thermometer if directly exposed to them.

Rainfall on weather charts is shown by isohyets (from the Greek *huetos*, 'rain'). All places on the same isohyet have the same rainfall.

Wind directions are shown by an arrow or line in the direction the wind is blowing (remember a wind is named by the direction from which it blows) with little ticks at the back of the arrow or line which give the speed of the wind. Winds of about 30 km.p.h. are what are called a fresh breeze; a strong wind blows at about 50 km.p.h.; a gale is round about 75 k.m. p.h. and a hurricane is any wind more than 100 km. p.h.

Some newspapers used to publish daily weather charts, but now they only seem to print figures of rainfall, which is a pity. If you know anyone who could show you a daily weather chart try to have a look at it. If you wrote to the Director-General of Observatories and asked for one, I doubt if he would have time to reply, but you could try—a nice polite letter with an offer to pay.

There is any amount, more than you can learn about the weather—names of the different winds and clouds, what causes mists and fogs, water spouts and dust devils, where and why and when there may be Hurricanes, Cyclones, Tornadoes or Typhoons, the causes of lightning and thunder, what are line squalls and so on; but here I will touch only on a few more occurrences in the world's weather.

Condensation of water vapour in the air is caused by the air being cooled and usually causes rain, but if the raindrops are frozen (they may be carried up to a great height by a rising current of air and there turned into little balls of ice) then they fall as hail. Snow is water vapour that has been frozen into ice crystals.

The temperature at which any air is saturated is called its dew point and if saturated air at ground level is cooled then dew forms on blades of grass and may even, if you are sleeping in the open, soak your blankets. If the dew is below freezing point, then it forms hoar frost. Have you ever seen hoar frost on the grass and leaves of plants ? It is very beautiful and worth getting up early on a cold morning to see if you are far enough north or high enough for it to happen.

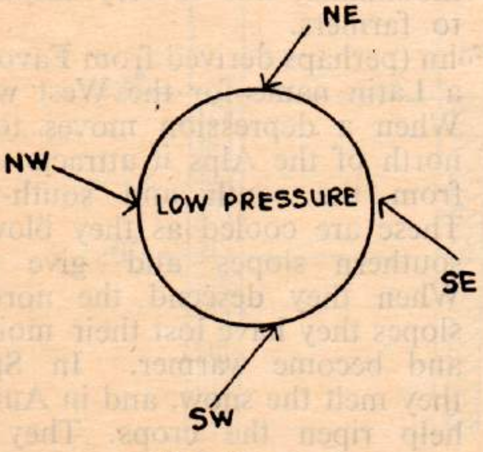


Fig. 39

In Chapter 7 we had noticed the difference in heating between the land and water and how this caused monsoon winds. The same difference in heating may have a daily as well as a seasonal effect along the coast or beside great lakes. Then the wind will blow off the sea in the evening and off the land to the sea in the morning, and these winds are known as sea and land breezes.

The cause of cyclonic depressions has been suggested in Chapter 7, but you ought to understand the directions of the winds they cause. The winds blowing into an area of low pressure—cyclonic winds—are affected by the rotation of the earth in the same way as winds blowing from or towards the equator as described in Chapter 7. That is, a wind blowing towards the equator loses on rotation, and a wind blowing away from the equator gains on rotation, while the winds blowing east and west are caught up in the swirl, so the winds in a cyclone in the

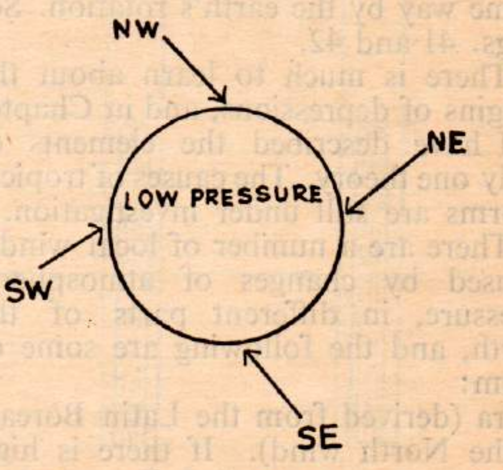


Fig. 40

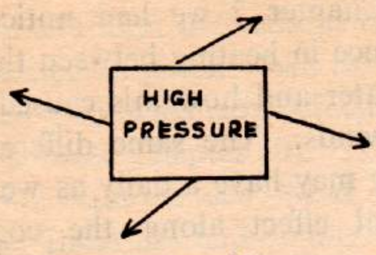


Fig. 41

Wind system in an anti-cyclone in the northern hemisphere

northern hemisphere are as shown in Fig. 39 and those in a cyclone in the southern hemisphere are as shown in Fig. 40. In Fig. 39 the winds blowing into the low pressure from the north are losing on rotation while those blowing from the south, from lower to higher latitudes, are gaining on rotation and the rest of the winds blowing in take up the anti-clockwise circulation.

In the southern hemisphere the effect is just the opposite. Winds blowing from the north, away from the equator, gain on rotation, and those blowing from the south, towards lower latitudes, lose on rotation and the system takes up a clockwise circulation.

An anti-cyclone is an area of local high pressure from which the winds blow outwards and are affected in the same way by the earth's rotation. See Figs. 41 and 42.

There is much to learn about the origins of depressions, and in Chapter 7 I have described the elements of only one theory. The causes of tropical storms are still under investigation.

There are a number of local winds, caused by changes of atmospheric pressure, in different parts of the earth, and the following are some of them:

Bora (derived from the Latin Boreas, the North wind). If there is high pressure over central Europe and low pressure over the Mediterranean Sea (from the Latin meaning the sea in the middle of the land), then a cold and usually dry wind from the north and north-east blows across northern Italy and along the eastern coast of the Adriatic Sea, sometimes with great violence.

Chinook (named from the North American Indian tribe from whose territory it blew). When a depression moves eastwards across North America it may cause south-westerly winds, and when these blow down the eastern sides of the Rocky Mountains into the south of the depression they are warm because they are descending. They often cause a rapid rise of temperature which melts the snow on the grasslands at the foot of the mountains; this is very important to farmers.

Föhn (perhaps derived from Favonius, a Latin name for the West wind). When a depression moves to the north of the Alps it attracts winds from the south and south-west. These are cooled as they blow up southern slopes and give rain. When they descend the northern slopes they have lost their moisture and become warmer. In Spring they melt the snow, and in Autumn help ripen the crops. They are similar in their importance to far-

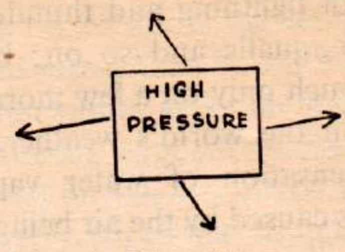


Fig. 42

Wind system in an anti-cyclone in the southern hemisphere mers to the Chinook winds of North America.

Harmattan (said to be derived from a West African word 'haramata' but what that means I have been unable to find out. Can you ?) This is a north-easterly wind blowing into the equatorial low pressure of North-West Africa. Since it blows from the Sahara Desert it is hot, dry and dusty. Inland it is unhealthy, but when it reaches the west coast, though its dust can cause haze, because it is so dry it causes evaporation and cooling, and is such a relief to people that it is known as 'The Doctor'.

Mistral (derived from the Latin for a master). Like the Bora, the Mistral is caused by high pressure over Europe and low pressure over the Mediterranean, mostly in winter. It is a cold north or north-westerly wind, particularly along the coast of France and it blows with great force down the lower Rhone valley where the trees grow leaning away from it, and where houses often have doors and windows only on their south sides.

Sircoco (derived from the Arabian 'Sharq', the East). When a depression moves eastwards along the Mediterranean the Sirocco may blow from the south and south-east ahead of it. Blowing from the Sahara Desert in North Africa, it is, like the Harmattan, hot, dry and dusty and damages crops. As it crosses the sea it picks up moisture and becomes humid, making people feel tired and bad-tempered.

Something to do after reading chapter 9

Answer the following and then look up each answer at the end after you have thought it out.

The following are sketches of various thermometers at a Meteorological Station in the morning, temperatures in degree centigrade.

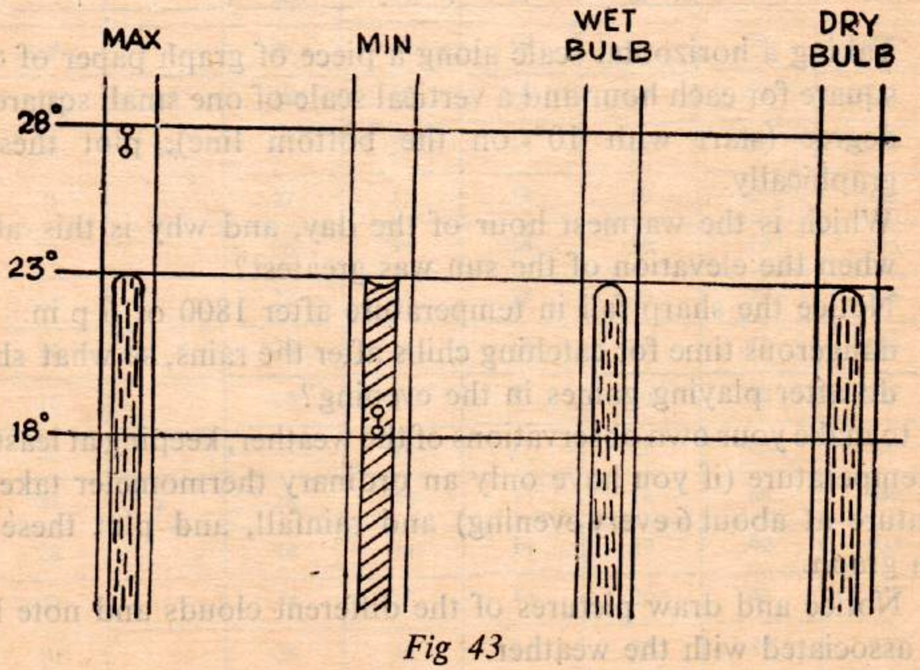


Fig 43

1. What would you record under the headings:
   (Give your answer before looking at the correct ones below:—)
   (*a*) Maximum temperature? (*b*) Minimum temperature?
   (*c*) Relative humidity?
2. The table on page 59 gives some weather statistics for the month of October (some years ago) in Dehra Dun:
   (*a*) Take a sheet of graph paper and using a horizontal scale of one small square (1/10″) a day, and vertical scales for rainfall of one small square for 3 mm, starting on the bottom line, and for temperatures of one small square for each degree, starting 3 inches from the bottom, show these figures as a graph.
   (*b*) When is the range of temperature (the difference between maximum and minimum temperatures) greatest and least?
3. The following table gives the hourly centigrade temperature observed in Dehra Dun on November 1st and 2nd.

TIME	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900
TEMPERATURE	18	21	23	24	24	26	26	27	26	5	25	20

TIME	2000	2100	2200	2300	2400	0100	0200	0300	0400	0500	0600	0700	0800
TEMPERATURE	19	18	18	17	17	17	16	16	16	15	14	15	16

   (*a*) Taking a horizontal scale along a piece of graph paper of one small square for each hour and a vertical scale of one small square for each degree (start with 10° on the bottom line), plot these figures graphically.
   (*b*) Which is the warmest hour of the day, and why is this after noon when the elevation of the sun was greatest?
   (*c*) Notice the sharp fall in temperature after 1800 or 6 p.m. This is a dangerous time for catching chills after the rains, so what should you do after playing games in the evening?
4. Try to make your own observations of the weather, keeping at least a record of temperature (if you have only an ordinary thermometer take the temperature at about 6 every evening) and rainfall, and plot these readings as a graph.

   Notice and draw pictures of the different clouds and note how they are associated with the weather.

Date	Rainfall in mm.	Temperatures in Degrees C				Humidity %	Barometer millibars
		Max.	Min.	Wet Bulb	Dry Bulb		
1		31	20	21	23	80	932
2	6	29	19	19	20	90	932
3		25	18	19	21	80	932
4	16	27	16	20	22	80	932
5		32	17	19	24	77	932
6		27	16	21	23	81	932
7	69	28	18	19	19	100	932
8	15	27	18	20	21	90	932
9	10	29	18	18	19	89	935
10		27	17	17	19	79	935
11		28	17	18	21	71	933
12		28	18	18	19	89	934
13		27	16	16	19	84	933
14		28	16	17	19	89	934
15		29	15	14	18	58	937
16		29	18	16	19	69	937
17		30	16	17	19	79	937
18		29	18	16	20	60	937
19	5	28	18	16	19	69	935
20	30	27	17	18	19	89	935
21		27	18	18	19	89	935
22		26	18	18	20	79	935
23		27	18	18	20	79	935
24		28	18	18	21	71	935
25		28	18	17	20	70	935
26		28	18	17	21	62	937
27	2	28	13	13	14	88	940
28		29	14	14	22	40	935
29		28	15	13	20	42	937
30		28	14	14	20	44	937
31		28	13	14	18	58	940

Answers to the questions at the end of chapter 9

1. (*a*) Maximum 27° (Not 28° because the mercury will have risen only to the bottom end of the indicator).

(*b*) Minimum 19° (Not 18° because the alcohol will have fallen only to 19° leaving the top of the indicator there).

(*c*) 100% (There is no difference between the readings of the wet and dry bulb thermometers, therefore there is no evaporation, therefore the air is saturated).

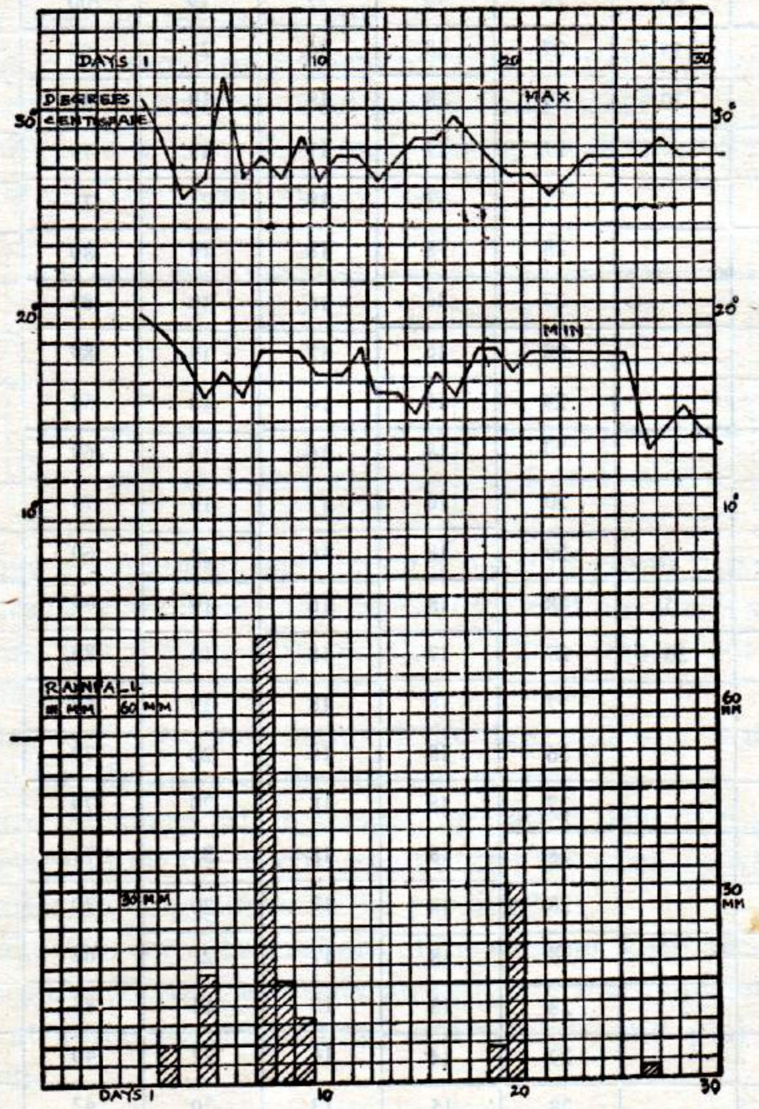


Fig. 44

2. (*a*) Your graph should look like Fig. 44.

(*b*) The range of temperature is greatest when the weather is fine, and least when there is rainfall.

3. (*a*) Your graph should look like Fig. 45.

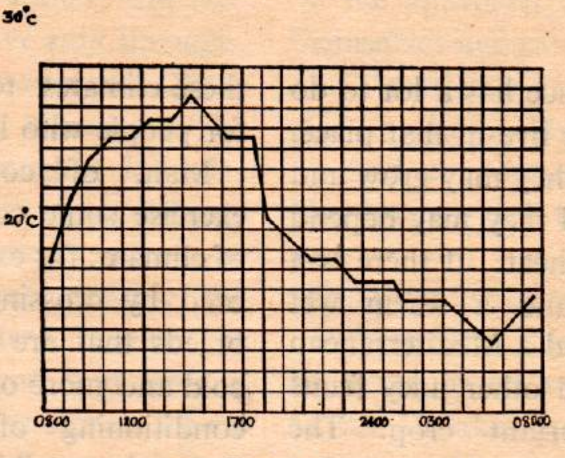


Fig. 45

(*b*) 3 p.m. It takes some time for the sun to heat up the land.

(*c*) Put on a sweater or coat.

10. *Something about Climate and Natural Vegetation*

The climate of a place has a lot to do with the way people live in that place. If it is hot and wet they may grow and eat rice; if it is cool they may depend for their food on wheat. If there is a hot dry summer and a warm wet winter (what is called a Mediterranean Climate) grapes and other juicy fruits will be an important crop. The modern textile industry (the spinning and weaving of cotton particularly) started in places like Bombay, and Lancashire in England, where humidity was high and the cotton thread was less liable to snap. The way people build their houses, and the clothes they wear, are largely controlled by the climate of the place they live in. Trade and exploration across the oceans were first largely controlled by the regular or planetary winds. In the past people tended to emigrate to places with climates similar to those they were used to—Indians to Malaysia, Guyana and South Africa, northern Europeans to Canada and southern Europeans to Brazil and the Argentine and the Chinese to Manchuria and southern Chinese to Malaysia. The humidity and tiring heat of tropical and equatorial climates make it more difficult for people with these climates to work hard than it is for people who live in cooler climates.

Man, of course, is learning to exercise some control over the effects of climate: for example, crops are being bred by crossing different strains or breeds that are resistant to heat and cold and more or less of rainfall. Air-conditioning of houses and offices makes it possible for those fortunate enough to be able to use it, to work in greater comfort and for longer hours. Cotton can be spun in dry climates in factories with artificial humidity. Climate, however, still largely controls the way we live, the plants, trees and grasses that grow around us, the food we can buy in the village market, the animals we use for agriculture and transport, and climate is the result of temperature, rain or snowfall, winds, height above the sea, ocean currents and distance from the sea.

There are four main climatic regions dependent on latitude: tropical, sub-tropical, temperate and polar and these can be further split up; for example, a tropical climate may have equatorial forests or hot grasslands known as savannah, or hot desert. A sub-tropical climate, again according to the rain it gets, may have what is called a Mediterranean climate when the Horse Latitudes stretch across it in summer time and it is hot and dry, and the westerly wind belt moves over it in winter bringing winter rain (see Fig. 38); or it may have rain throughout the year and be known as a China type or Cotton Belt climate. The temperate regions (roughly latitudes 40° to 60°) may have their climate warmed by ocean currents and so be what is called temperate oceanic, the climate of north-western Europe; or they may be far inland and have a small rainfall and steppe climate whose natural vegetation is grass, and here wheat is the great crop; or they may have very little rain and be a desert like the Gobi Desert. In the polar region there is the Tundra where the ice melts in the summer and flowers, mosses and lichens flourish for a few months, and also the ice cap which never melts. In any part of the world the climate may be changed by mountains which will have a mountain climate.

Different climates have their different natural vegetation. Where there is good rainfall there will be trees—evergreen where it is hot, deciduous where it is cooler. Deciduous trees are trees that shed their leaves; and those with which you are most familiar, I expect, are the trees of the monsoon forests of India which shed their leaves during the hot season, possibly to protect themselves against losing too much moisture by evaporation from their leaves. Where it is cooler still, round some hill stations and in warm temperate climates, the trees shed their leaves on the approach of winter to protect themselves against the cold and frosts. The Americans call the time they do this 'the fall'. Where it is cooler still we find coniferous trees with needle-like leaves, and these you will have seen if you have ever been to the Himalayas or other high hills.

Where there is less rainfall there will be fewer or no trees and grasslands. Savannah takes the place of equatorial forest as the rainfall grows less with distance from the sea, and here there are scattered trees and tall grass that flourishes when the rain falls in the hot season. This is the region of herds of antelope and the animals that feed on them, and where man often keeps many cattle. Where there is less rain still there is desert; and where it is cooler the savannah changes to temperate grasslands: the steppes of Europe and Asia, the prairies of North America, the pampas of South America, the veld of South Africa, and the pastures of New South Wales in Australia.

Let us look for a moment at the climate of India. But before we do this let me tell you how I drew India's rough outline for the figures below. I made a templet by tracing the outline of a map of India on to a piece of card and then cutting round the outline.

Such a templet is a useful thing to make and keep as you will need to draw lots of maps of India, and it will save you much time.

Fig. 46 shows the rough position of three isotherms, those of 15, 20 and 25 degrees Centigrade, over India and the countries next to it in December, and Fig. 47 shows isotherms 30 and 35 degree centigrade in June.

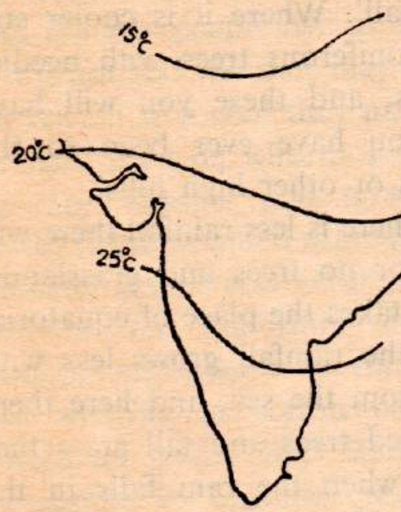


Fig. 46

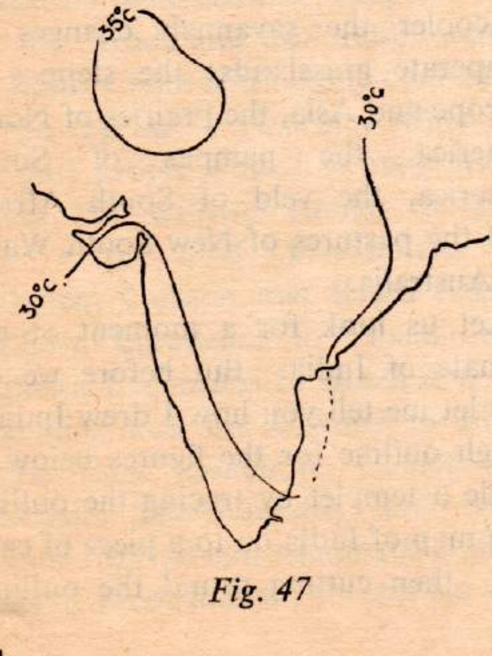


Fig. 47

In December it gets warmer as you go southwards to lower latitudes, as we would expect, and the land tends to be cooler than the sea in the same latitude—look how the isotherm of 25°C bulges southward over the land.

In June, however, it gets hotter as we go northwards and the land is warmer than the sea in the same latitude, and the hottest part of India is in the north-west over Rajasthan and the Punjab.

It is this great heating of the land mass of India during the dry sunny months from April to June that causes its monsoon climate. The heated air rises over the hot land, the pressure is lowered and moisture-laden winds blow in from the sea from the S.W. from the Arabian sea, and from the S.E. deflected eastwards by the Himalayas, from the Bay of Bengal.

The heaviest rain brought by these winds will be where they have to rise over mountains, along the Western Ghats and on the southern slopes of the Himalayas. That is why the rivers flowing from the Himalayas are so liable to floods. Rain over the plains of India is more the result of local currents of rising air than of hills. These currents, known as convection currents, and often associated with thunderstorms, you must learn about later. Where a moisture-laden wind has shed much of its moisture blowing over a range of hills, and descends and gets warmer the far side of the range, it will shed little more rain, and the far side of the hills is said to be in a 'rain shadow' That is why Poona gets so much less rainfall than Bombay.

Perhaps the easiest way to appreciate climate is to look at graphs showing the rainfall and temperature of places with different climates. The daily temperature of any place is normally found by adding the maximum and minimum and dividing by two. The mean monthly temperature is the average temperature of all the days of the month, often for a period of years. The monthly rainfall, unless given for any particular year, is the average monthly rainfall for a period of years. Fig. 48 shows the maximum and minimum temperatures and the rainfall for one year in Delhi, the horizontal scale being one small square a month, and the vertical scales as marked. This is a typical graph of a monsoon climate in central northern India. Note the rapid rise of temperature from January to May, the sharp fall of the maximum during the rains and the more gradual fall of the minimum, and then the slight rise in the maximum in October while the minimum begins to fall fast, and finally the fall of both maximum and minimum. The rise of the maximum in October is because the rains and clouds have almost gone and the sun shines hot again, while the minimum falls during clear nights. During the rains the range of temperature is smaller because clouds shade the sun during daytime and act as a blanket at night, preventing the more rapid loss of heat there is on a clear night.

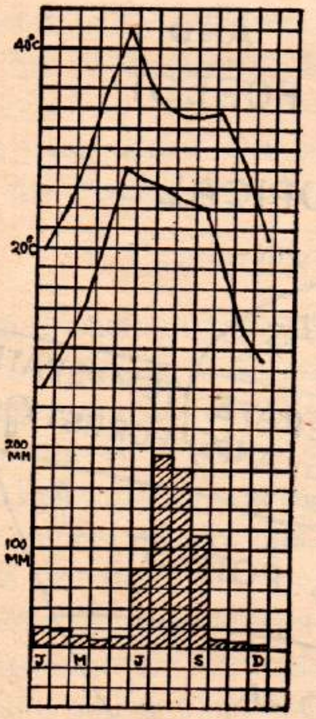


Fig. 48

You will find statistics for some other typical climates in the exercises at the end of this chapter.

Finally, I want you to see how the natural vegetation regions of the world, fertile or desert according to climatic regions, can be shown on an imaginary continent stretching from pole to pole. From this diagram you can work out what the vegetation is likely to be in any actual continent; but remember the effect of mountains, and remember too that this is only a diagram on a very small scale, and so can give you only a general idea of basic principles that, in any actual place, may be

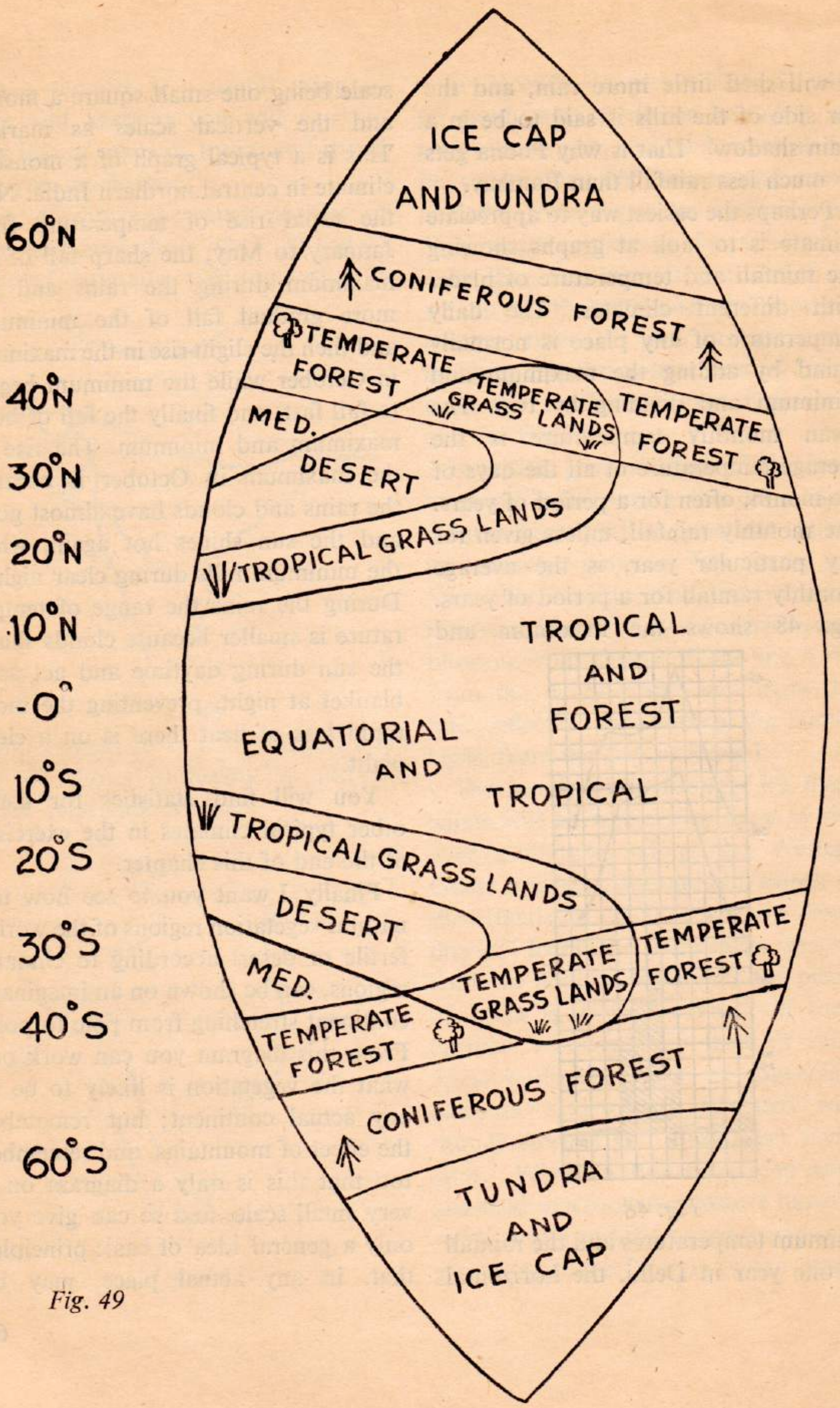

60°N
40°N
30°N
20°N
10°N
0°
10°S
20°S
30°S
40°S
60°S
ICE CAP AND TUNDRA
CONIFEROUS FOREST
TEMPERATE FOREST
TEMPERATE GRASS LANDS
TEMPERATE FOREST
MED.
DESERT
TROPICAL GRASS LANDS
TROPICAL AND FOREST
EQUATORIAL AND TROPICAL
TROPICAL GRASS LANDS
DESERT
MED.
TEMPERATE GRASS LANDS
TEMPERATE FOREST
TEMPERATE FOREST
CONIFEROUS FOREST
TUNDRA AND ICE CAP

Fig. 49

altered by local conditions.

Look at Fig. 49, and I will explain it a little. Starting from the equator we find the belt of equatorial and tropical forest wider on the east side of the continent because that side gets rain from the Trade Winds when they have blown over the ocean. On the east side of the continent the tropical forest changes to temperate forest as we go to higher latitudes because it gets cooler, while on the west side the forest turns into tropical grasslands as it gets drier and then into desert; by the time the Trade Winds have crossed the continent they have lost any moisture they were carrying, and the convectional rainfall from the belt of rising air in the doldrums grows less and less with distance from the equator.

On the west side of the continent, between the deserts and the regular rainfall brought all the year by the westerly winds, are areas which get winter rain from the southward shift of the south westerlies as the sun comes over the Tropic of Capricorn, and the northward movement of the north westerlies as the sun comes over the Tropic of Cancer. These areas have a Mediterranean climate.

In the centres of each half-continent, far from the rain-bearing winds from the oceans, are areas with temperate grasslands, while, as rainfall increases towards the oceans, there is temperate forest. Then, as we go towards the poles, first there are the belts of coniferous forest, and then the Tundra and permanent ice. The ice caps stretch into lower latitudes on the east side of the continent because the westerly winds, which will have been blowing over 'warm' currents, make the west side of the continent warmer than the east.

Something to do after reading chapter 10

1. With the help of your atlas (*a*) make a list of the deserts on the west sides of land masses and name the countries in which they are; (*b*) make a list of countries (or regions of countries) which should have a Mediterranean climate.

2. You have already studied a monsoon climate with its hottest month before the summer solstice and a slight rise of temperature when the rains stop. Here are the mean monthly maximum and minimum temperatures in degrees Centigrade and the average monthly rainfall in mm. of four places, one near the equator (tropical forest), another a place with a Mediterranean climate, another a place with a temperate oceanic climate (deciduous forest), and another with a temperate continental climate, not in that order. Make graphs of the temperature and rainfall of those places and write down which climate you think each has.

Month		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
A	Max	−7	−6	−1	9	18	22	23	21	14	8	0	−4
	Min	−14	−13	−7	−2	4	11	15	11	8	1	−4	−9
	Rain	30	20	33	38	45	50	69	71	56	20	30	25
B	Max	30	31	31	31	31	30	30	30	30	30	30	30
	Min	22	23	23	23	23	23	23	23	22	22	22	22
	Rain	251	170	190	189	167	170	167	188	178	211	284	257
C	Max	10	13	14	17	20	24	26	27	25	19	13	9
	Min	3	4	4	6	9	13	14	14	13	9	5	3
	Rain	71	58	63	69	71	81	51	58	66	91	90	71
D	Max	28	29	27	26	21	18	17	17	19	20	24	27
	Min	17	17	16	14	11	10	9	9	10	12	13	16
	Rain	8	10	18	43	129	177	170	145	89	56	18	19

Answers to questions at end of chapter 10

1. (*a*) California Desert — U.S.A. and Mexico
Atacama Desert — Peru and Chile
Sahara and Libyan Deserts — Morocco, Spanish West Africa, Mauritania, Mali, Algeria, Niger, Tunisia, Libya, Chad, Egypt, Sudan
Arabian Desert — Saudi Arabia
Namib and Kalahari Deserts — South West Africa
Thar Desert — India and Pakistan
West Australian Desert

(*b*) Northern California, the countries round the Mediterranean, central Chile, the south of Western and South Australia.

2. A. Temperate Continental. Note the bigger range of temperature than in C. The place, which you are not expected to know, is Moscow.

B. Equatorial. The range of temperature is very small; it is always hot, and there is heavy rainfall throughout the year. The place is Singapore.

C. Temperate Oceanic. There is rain throughout the year, heavier than in Moscow because the winds come off the sea, and the range of temperature is less for the same reason. The place is Bordeaux.

D. Mediterranean. Were you caught out by its being in the southern hemisphere? There is a warm wet winter and a hot dry summer from October to April. The place is Perth.

11. Something about map projections

As you know, it is impossible to show the spherical earth's surface on a flat piece of paper, and yet we want to do so, so we have to put up with falsehoods, misrepresentation, or distortion. The smaller the area mapped, the less false it is, but if we want to show the whole or even half the surface of the earth as flat there has to be a great deal of pulling and stretching and distortion. We can pull out the surface of the sphere in all sorts of ways to try to get it flat. We can even cut it into bits, squash each flat, and piece them together. There are a great many different map projections, and if you want to know much about them you will have to read a book on them. I am trying to give you only a general and rough idea of what happens.

The word 'projection' comes from Latin and means stretched out or 'thrown in front' and a map projection can be either a drawing according to calculations, or a map made by imagining a light in the centre or at the side of a globe on which parallels and meridians have been drawn, throwing the shadows of these parallels and meridians onto a piece of paper rolled round the globe or tangent to it at some spot.

The choice of the projection used depends upon what the map is needed for: the whole world, a hemisphere, smaller areas, correct directions, equivalent areas, and so on. Get into the habit of looking at the name of the projections of maps in your atlas and noticing the differences between them.

One common projection to show the whole world is Mercator's, which is drawn according to calculations. The equator is a straight line of given length divided into 360 parts, one for each degree of longitude. The meridians are drawn as perpendiculars through the points of division (of course, they may be drawn through every 10 or 20 or any convenient number of points) and are therefore parallel to each other instead of, as they do on the earth, meeting at the poles. Hence, except at the equator, there is east-west stretching on the map which increases with distance from the equator. In order to keep all angles correct, which is what Mercator wanted, there must be an equal stretching north and south, so where the east to west exaggeration is double (at parallels 60° N and S) a double north and south stretching is made. This increases the area at 60° N or 60° S four times.

This is illustrated in Fig. 50. If ABCD is an area of the world's surface at 60° N or S, on a map where the

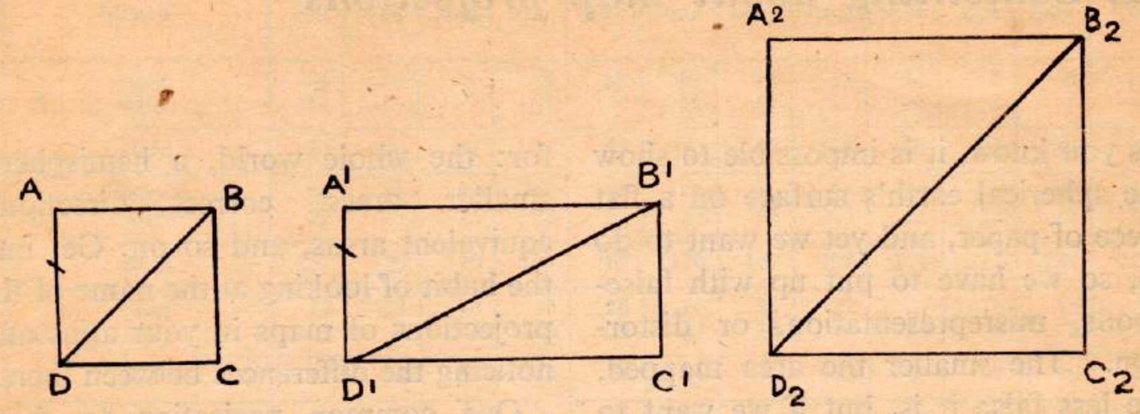


Fig. 50

meridians are shown parallel the real distance DC will be stretched to $D_1\ C_1$ and if you want to keep the direction DB correctly you have to stretch the distance between the parallels equally, and $D_2\ B_2$ is again NE.

Because of this exaggeration of area, Mercator's projection is seldom shown beyond 80° from the equator, and an example of the distortion it causes can be seen by comparing the sizes of Greenland and South America. South America is actually more than twelve times the area of Greenland, but on a Mercator's projection it looks smaller! However, the advantage of Mercator's projection is that all angles are kept the same as on the globe, so compass bearings can be correctly measured on the map and it is used for sea charts and maps, such as those showing winds and sea currents, where true direction is wanted.

Another projection to show the whole world is Mollweide's Equal Area Projection. This too is a drawing according to calculations. It shows the world as an ellipse with the equator as the major axis twice the minor axis from pole to pole. Parallels are straight lines divided off along the central meridian at distances decreasing as latitude increases, that is with distance from the equator. Meridians, except the central one which is a straight line, are curved to meet at the poles. Now a meridian is a north-south line, so these curved meridians are not direction true. Also with distance from the central meridian, they get longer although on the globe all meridians are of equal length; so distances are not shown truly on the map. What, however, is kept true is area. Areas towards the edge of the map are pulled out north and south, but are narrower east and west than central areas. A north-south stretching is balanced by an east-west compression, and the areas are kept equivalent all over the map. Distortion is greatest at the edges of the map, but if the map is drawn with the oceans and polar regions at the edges and the land regions round the middle, Mollweide's Projection is a good one for showing the share of different countries of different products, for example the different areas under wheat or with forest, or desert.

To show a hemisphere a plane projection is often used. For this the surface on which the map is to be drawn is put tangent to the globe at the point which is to be the centre of the map. Points on the map are placed correctly according to their azimuths or bearings from the centre, corresponding to their true bearings on the globe. If the centre of the map is one of the poles the parallels of latitude are shown as circles around it and become longer on the map than the corresponding parallels on the globe. Although bearings are correct from the centre of the map, east-west parallels will not be straight lines, so bearings from any other point on the map will not be correct. If it is wanted to show equivalent areas the scale of the map can be reduced gradually along the radii from the centre (that is along the meridians if the map is tangent at a pole). If the centre of the map is at any other point than a pole then the radii and circles will not be meridians and parallels, but the meridians and parallels are drawn in.

In a simple cylindrical* projection the surface on which the map is to be drawn is rolled round the globe to make a cylinder* touching at the equator. The meridians are projected on the cylinder up and down at right angles from the points of contact along the equator, and the parallels of latitude horizontally from the north-south axis of the globe. When the cylinder is then unrolled the meridians and parallels are straight lines at right angles to each other, and the poles which should be points, become lines as long as the equator. Also the intervals between the parallels decrease towards the poles instead of remaining equal as they are on a globe. Mercator's projection is a modification of, or a changed sort of, cylindrical projection.

A simple conical projection is made by fitting a hollow cone (if you like, a dunce's cap) over the globe with its point or apex over the pole and its inside tangent to the globe on the parallel of latitude through the centre of the part to be mapped. The circle of this tangent is drawn on the cone, and also a line from the apex of the cone through the centre of the part to be mapped. This becomes the central meridian of the map. The cone is then removed and cut open from the apex down the centre opposite the central meridian. What was the circle of the tangent now becomes an arc or part of a circle of the same length as the parallel on the globe to which it was

---

*Cylinder comes from the Greek *kulindors* meaning 'roll' tangent. This arc is now divided into 360 equal parts and each will be exactly as long as one degree of longitude on the globe along that parallel. The central meridian on the map is also divided, each part being made as long as one degree of latitude on the globe, and arcs are drawn through these divisions with their centre the old apex or the cone. Finally, radii are drawn from this centre through the 360 divisions (or at intervals of 10, 20 or whatever degrees are suitable) along the circle of the tangent to represent meridians of longitude. These maps are correct along the parallel that was tangent to the globe but there is stretching east and west the further you get from it. If, however, only a small part of the whole cone is used, the error is not great, and this sort of projection can be used when only a part of the globe is to be shown.

In Bonne's projection the parallels are drawn as described for a simple conical projection, but all the degrees of longitude are measured from the central meridian along every parallel according to their true size. The curves connecting these divisions represent meridians, but they do not cut the

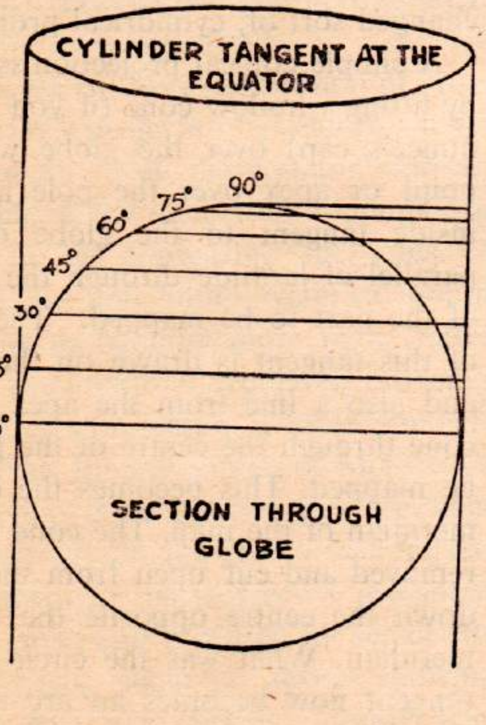


Fig. 51

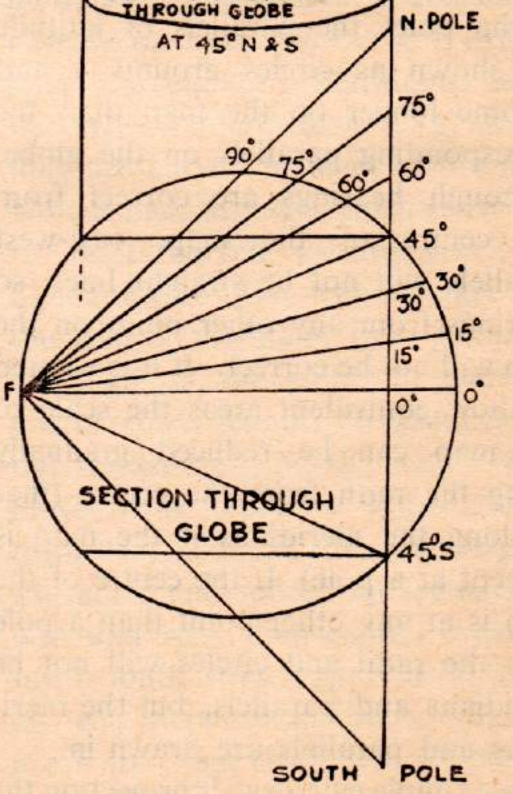


Fig. 52

parallels at right angles. This makes a map with map areas equivalent to areas on the globe, but distortion of shape increases with distance from the central meridian.

Both cylindrical and conical projections can be made by imagining the cylinder or cone cutting through the globe at two parallels instead of tangent at one, and so reducing distortion. I have drawn Figs. 51 and 52 to show what is meant.

Fig 51 shows how a simple cylindrical projection is made. The focus of projection is infinity—that is, the rays from the source of light projecting the globe on to the cylinder are parallel. The intervals between parallels on the cylinder grow less with increasing latitude, and the length of the parallels equals the circumference of the globe throughout. The length of meridians is the same as that of the axis of the globe.

Fig. 52 shows Gall's Projection with the cylinder cutting through the globe at parallels 45° N and S and the focus of projection along the equator. The length of all parallels will equal those at 45° N or S, and the length of all meridians, you will realise if you are expert at geometry, will be the hypotenuse of a triangle with a right angle at the focus of projection and the base the line joining parallels 45° N and S produced to meet the arms of the right angle.

If you are making a map of a very small area of the earth's surface, you need not worry about map projection —just draw it to scale and true bearings, but in maps of large areas, properties such as correct areas, true shape, true bearings, the same scale all over the map, cannot all be included on any one map. Adjustments have to be made to secure the property you want for any particular map, and these can be made in very many ways of projecting the globe. I hope I have described enough for you to realise some of the problems involved. If you want to become an expert you must study more than I can put into this chapter.

Having drawn the network of parallels and meridians, you then plot the positions of places according to their latitude and longitude on the earth's surface and proceed to draw in the boundaries of continents, countries, islands, seas and so on.

Something to do after reading chapter 11

Borrow a large atlas and make sketches from it of the different sizes and shapes of Greenland and South America as shown on maps drawn to different projections. Write down the name of the projection, its scale, and what it was drawn to show. Useful but long words to know (though they will cause arguments if you use them playing Scrabble) are

Homolographic — equal-area
Orthomorphic — right shaped
Azimuthal — showing true bearings from the centre

12. On making a map or plan

If you want to make a map, the first thing is to find out where you are. You can normally do this by using a map made by somebody else and finding your position on it, but we will start from the beginning. You take a point on the earth's surface and fix its position by finding its latitude and longitude. This would be done by a surveyor* and the surveyor would do it much more accurately than we have described in Chapter 8. He would make use of stars and planets, but we will leave you to learn how that is done later in your life if you need to.

Having fixed the position of one point you fix that of another in the same way, and measure the distance between these points. A surveyor would do this with great accuracy, using a tape or wire made of a metal that does not expand or contract with changes of temperature. The measured line between the two fixed points is known as a Base Line and from each end of it the positions of other points can be fixed by taking their bearings with an instrument called a theodolite and drawing similar triangles to scale on your map. If you were making a map of a whole country like India you would first have to carry out what is called a 'primary triangulation' in which the fixed points would be too far apart for detailed survey. This primary triangulation was gradually done for India by the Survey of India, another of the very fine services of the country, and two great names in this work are those of Lambton (1750-1823), and Everest (1790-1866) after whom the great mountain was named.

For more detailed map making the triangles of the primary triangulation have to be broken down into a series of much smaller ones. This can be done using a plane table. The surveyor starts with a sheet on which have been plotted, to the scale required, the fixed points of the primary triangulation and from these points the plane tabler fixes the position of many new points : hill tops, tall chimneys, temple tops, prominent trees and so on by triangulation. He also uses a clinometer to fix heights. The details of the map are then drawn in.

A plane table is a board fixed on a tripod † with an adjustable head so that the board can be tilted and rotated. The centre of the board with the sheet to be made into a map fixed to it is put exactly over a fixed point and the plane table made level with the help of a spirit-level, a horizontal glass tube with spirit and an air bubble in it, which shows, when the bubble is in the centre of the tube, that it is level. Then, with the help of a sight rule, the base line on the sheet is lined up with the base line that has been measured on the ground.

---

*From an old French word meaning to 'look over', meaning here a man who looks over the country to make a map.

†From the Greek for 'three feet'.

A sight rule is a ruler with flaps at each end that open to stand at right angles to the ruler. There are slits in each flap so that you can look through one end of the ruler and align the other on any object whose position you wish to fix. Having done that you rule a line on the map from your fixed point towards your object. You may well choose several objects. Then you go to the fixed point at the other end of the base line, set up the plane table in the same way, making sure the base line on the map is aligned back along the base line on the ground, and draw lines with the help of the sight rule to the objects you chose from the other end. Where the two lines sighted on any one object meet, there is the position of that object on your map. The triangle on your map will have the same angles as the triangle on the ground, so they are similar triangles and their sides will be in the same proportion as the scale you have chosen is to distances on the ground. When you have fixed enough positions in this way you draw in details on the map by eye.

Heights are measured by a clinometer, which is another sort of sight rule from which you can read the angles between the horizontal where you are and the point whose height you want to know. This must be a fixed point so that you have its distance, and this multiplied by what is called the tangent of its angle of elevation above the horizontal works out its height—a bit of trigonometry I won't worry you with, but you can ask a mathematician to explain it to you. All you need to realise is that if you draw right-angled triangles on the same base—the distance between you and the object whose height you want to find—there is a fixed ratio or relationship between the different heights and the angles subtended by them.

On the map the surveyor can draw lines known as contour lines connecting places the same height above the sea. These lines show where there are hills and valleys and are drawn at convenient intervals according to the scale of the map and the lie of the land (see Chapter 14).

From other fixed positions and soundings to find the depth, charts of the sea bed are made by the Hydrographic* Department of the Navy.

Nowadays man has invented such wonderful instruments that accurate

---

*Greek *hudros* 'water'

maps can be made from photographs taken from the air, but what I have described is, I hope, enough to give you an idea of the basic methods of map making; and doing something is a much better way of learning about it than just reading, so I have kept this chapter short, to give you time to go out and make a plan or map for yourself.

Something to do after reading chapter 12

Get together the following:

1. If you can, borrow a plane table; but that will probably be difficult, so take any light table.

2. If you can, borrow a spirit level (a carpenter might have one) but if you cannot, then make something for yourself that will show whether the top of the table is level or not. (You could carry a shallow tin and a bottle of water.)

3. If you can, borrow a sight rule, but if you cannot then put two nails upright in the two ends of a ruler so that you can line them up with any object whose direction you want to record.

4. Borrow a compass, an instrument for showing direction. If you can't do this, then you can judge direction only very roughly. One way to do this when the sun is in the South, is from the shadow of an upright pole. At 6 a.m. it will point roughly west, at 7 a.m. roughly 285°, at 8 a.m. 300°, at 9 a.m. 315°, at 10 a.m. 330°, at 11 a.m. 345°, at noon north, at 1 p.m. 015°, and so on. Another rough way to find direction is to mark the ends of the shadows of an upright pole at an interval of about half an hour. If you join these two marks, the line joining them will point roughly from west to east. This method is accurate only at or near the equinox or when used at times near to local noon.

5. Borrow a tape measure. If you can't, use a bit of rope and measure it off in lengths of 10 metres, tying a knot at each 10 metres and 10 knots at one metre each at one end.

6. Pin a sheet of paper onto the table top. If you are not allowed to do this, then pin it onto a board that will be flat on the table.

Now go out into a field or garden or park and make a plan of it. Proceed as follows:—

(*a*) Choose a scale that will allow you to get it all as large as possible onto your sheet of paper, perhaps 1 cm=10 m.

(*b*) Take two positions at the ends of a base line and measure the distance between them. You could put a book or stone down at each position.

(*c*) Draw this line on your paper to scale. Take your table to one end of the base line, level it and put the end of your drawn line over the same end of the base line on the ground and using your sight rule turn the table or the board on it, till the line on the paper points along the line on the ground. Take care that the table remains level.

(*d*) Put one edge of your sight rule against the point on your map from which you are making observations, and along that edge of the ruler draw lines towards objects whose positions you want to fix on your plan.

(*e*) Go to the other end of the base line and repeat (*c*) and (*d*).

(*f*) Having, in this way, fixed the positions of various things—trees, corners of the field and so on, draw your plan.

(*g*) On your plan mark the direction of north, and write down the scale.

(*h*) Measure the distance on the map between two trees. Then measure it on the ground and see how accurate you have been able to get your plan.

13. *On reading a map*

Look in your atlas at a map of the world on Mercator's projection which gives correct bearings, and find Anchorage, the capital of Alaska, and Leningrad. The position of Anchorage is about 61° N 150° W and of Leningrad 60° N 30° E, so if Anchorage is not marked you can find where it is. Now, if I asked you in what direction you would fly from Leningrad to Anchorage you might say more or less due west along parallel 60° N. But if you did you would be wrong. The shortest distance on the map is, of course, the straight line joining the two places, but on the earth it is along the Great Circle joining them. A Great Circle is any circle on the earth's surface that divides the earth into two equal parts. The equator is the only parallel of latitude that does this. All meridians are half of a great circle and a great circle can be drawn through any two places on the earth's surface. Look at a globe, or if you haven't one take your ball and check this. On your ball draw a circle round the North Pole at about latitude 60° N. Mark as near as you can the positions of Leningrad and Anchorage. Then take a bit of string and find the shortest distance between them on the globe or your ball. It will not lie along parallel 60° N. but, except at the two places, will be north of it, and will go very close to the North Pole. That is why some airlines fly within the arctic circle although they may be flying between places outside the circle.

I have drawn your attention to this so that when reading small-scale maps in your atlas, you remember what was written in the chapter on map projections. No small-scale map of a large part of the earth will be accurate for distance, direction and shape together. Always look at the name of the projection and see what the map has been drawn to show.

However, in a large-scale map of a small part of the earth's surface where the curvature of the earth is hardly noticeable, we need not, for the present, worry about map projection; and we can take it that scale and direction are true all over the map. So I want you now to consider a sheet of a Survey of India map to a scale of R.F. 1 : 100,000 (1 cm = 1 km), 1 : 50,000, or 1 : 63360 (1″ = 1 mile). You will have to try to get hold of such a sheet, but even if you cannot, or can only get one on a smaller scale, I can tell you something about it.

It is extraordinary to realise how much information is given on this one large sheet of paper. If you tried to put into words all that the map tells you, you would have to write a a book of well over 100 pages of small print, and even then you would have to leave out many details.

First, look at all the information in the margins round the edge of the map. The heading names the part of India shown in the map and the number of the map sheet, and you are told the date when the area was surveyed and below the map the date when the map was revised and published, so you will know that it will not show roads and buildings, railways, dams and reservoirs or anything that has been made since then. At the top also is information about Grid and True North and magnetic declination, which you will need for measuring directions and which I will explain below. Round the edges of the map are given the numbers of the grid lines, and the parallels of latitude and meridians of longitude that are shown on the map. Underneath the map are its scale, and explanations of the signs used on the map for different gauge railways, different sorts of roads, different sorts of buildings—temples, mosques, churches, dak bungalows, post offices, and so on—and things like boundary pillars, Trigonometrical Stations, Bench Marks, height above sea level and other things. If you are lucky you may be able to find a Bench Mark in your own neighbourhood. It will usually be a stone with an arrow with a line above the arrow cut in it, and this is a point whose height and position have been very accurately found by a surveyor.

In the bottom margin of the map will also be an explanation of the colours used on the map and a statement of the intervals at which contours are drawn.

Let me now say something of the grid and direction. So far we have been used to naming position by the intersection of parallels and meridians and you will remember that 1 degree of latitude is divided into 60′ and one minute of latitude is divided into 60″. One second of latitude is a nautical mile (for long this has been taken as 6080 feet, but the International Nautical Mile is now defined as 1852 metres, nearly 4 feet shorter) and when ships or aeroplanes give their speed in knots they are stating it in nautical miles per hour. The word 'mile' comes from the Latin for 'a thousand' and is derived from the old Roman measure of 1000 paces. The Romans must have taken long steps because their mile was about 1,618 yards. Notice that the nautical mile is longer than the statute mile (5280 feet) by which distances used to be measured before the metric system was introduced in India. A metre, by the way, is 1/10,000,000 of the distance along a meridian from the equator to the North Pole.

But to get back to naming positions. As parallels of latitude drawn one second apart are, on the ground, a nautical mile or over a kilometre and a half apart, such lines are too distant from each other to be used for the accurate naming of a position. Therefore large-scale maps are now usually covered with a network of lines forming small squares called a grid. On a map with a metric scale these lines will probably be at distances of 1,000 meters apart on the ground. and on a map of one inch to a mile they may be 1,000 yards apart. Positions are described by reference to the numbered lines of the grid but when doing so you have to remember this : when using latitude and longitude, latitude is always given first; but when using the grid you name first the line to the left or west of the position you want to describe, then the number of tenths between this line and the next to the right. Then you name the line below or south of the position, then the number of tenths towards the line above it. Look at Fig. 53 and this will, I hope, make my meaning clear.

If you want to give the position of the spot marked with x at *A* you first name the line on the left 08, then you estimate how many tenths of the distance from 08 to 09 it is—say three —and write down 083; then you name the line below it, 32, and

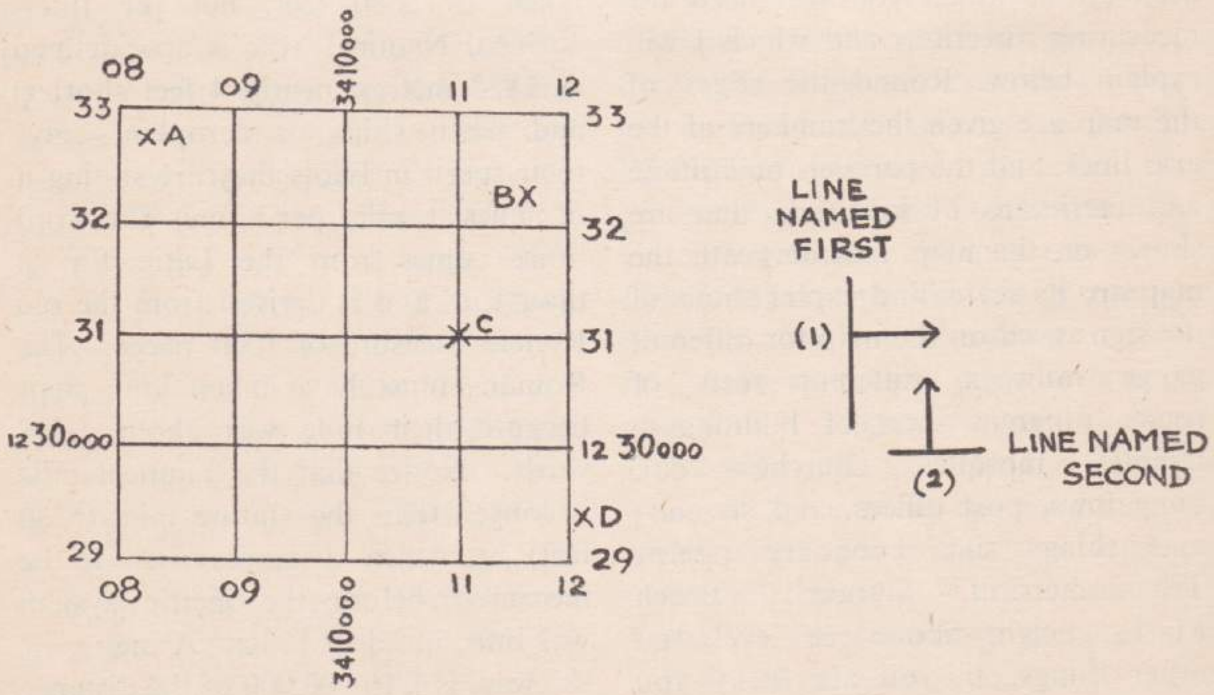


Fig. 53

estimate how many tenths it is between 32 and 33—say 8—and write down 328. The Grid position is then 083328.

Some of the grid lines may be numbered in more than two figures, for example in our figure 1230000 and 3410000. You take no notice of the smaller figures and use only the ones in larger print.

Now write down the position of the crosses named *B*, *C* and *D* before looking below at the correct answers and then check whether you have got them right.

Answers :		
	B	116323
	C	110310
	D	121294

The vertical lines of a grid will not usually be exactly north and south, but they are useful for measuring directions, so, on the map you will be told how far grid north is east or west of true north. Suppose for Fig. 53 it was stated that mean grid north was 4 degrees east of true north, this would be the exact bearing of the central north-south line of the grid. The other north-south lines should, of course, meet at the North Pole, but the difference this would make to their directions on a map like this could not be measured. So we take every line to be 4 degrees east of true north. Now, if you want to measure the direction of *A* from *D* you join them and read off the angle of this line to the west with your protractor along any convenient N-S grid line. If you do it you will find it is about 50 degrees, so the direction by Grid is N 50 W or 310 degrees. This has to be turned into a true direction. If you think carefully you will realise that all Grid directions are 4 degrees less than the true direction. In Fig. 54, I have made Grid North 20 E of True North so that the difference can be more easily seen. If from *O* the Grid direction of *OB* is North, you can see its true direction is 020°, so we get the rule 'Grid north to true north, easterly error add'. You can remember this by the letters G T E A. Conversely, if we want to find what a True bearing will be according to the Grid, you can see that the direction *OA* in Fig. 54 will be 20 degrees less than north by the Grid, so true to Grid, Easterly subtract and the Grid direction of *OA* is 340°. If the grid error is west of true north, then 'Grid to True, westerly error subtract', and 'true to grid westerly error add'. Draw a figure with the Grid north-west of true north and work this out for

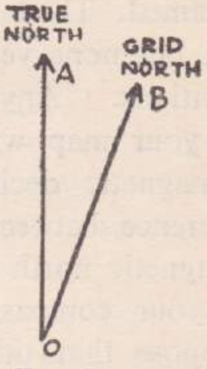


Fig. 54

yourself.

There is another slight complication to deal with while we are thinking of direction. Your compass, if you have one, and it is an accurate one, will point, not to the true north, but the magentic north. Where magnetic north is and how its position varies have been learned from observations, but why it varies has not yet been completely explained. There are a number of theories, but none yet explains all the observations. Anyway, on the margin of your map will also be a note on magnetic declination, that is the difference between true north and the magnetic north to which the needle of your compass will point. Let us suppose that this note reads 'Magnetic declination about 1° W in 1960 (increasing annually by about 3′). By 1970 the magnetic declination will have become 1°30′. From your compass you must subtract 1° 30′ from your compass reading; and if the declination was east you would have to add.

All this about bearings is to assist you to find your way about with the help of a large-scale map. If you know where you are on a map and want to walk across country to another place marked on it, measure the direction or bearing on the map of the place you want to go from the place where you are, turn this into a compass bearing and march ahead on that bearing, looking at your compass from time to time—or marching on some tree or hill top or other distinct feature—to make sure you are keeping in the right direction.

If you are in a bit of country of which you have a map, but don't know where you are, then use your compass to take the bearings of two or three features which you can recognise both on the map and where you can see them around you, and work out their back bearings, that is the direction from them to you: 180° from the direction from you to them. Draw lines lightly on the map from these features according to their back bearings, and where they meet, or within the little triangle they make (little if you have measured accurately, large if not) will be where you are.

We have still to think about contours, but we will leave them to the next chapter.

Something to do after reading chapter 13

Beg, borrow or—no, I won't suggest you should steal—but try to get hold of a large-scale Survey of India map of the area where you stay, and see what you can learn from it. Use it for a cross-country walk. Find any wells, forts, canals, temples, graves and so on marked on it. As you get used to reading a map you will find there are a great many interesting things you can do with it.

14. Contour Lines

(A Programmed Lesson)

A contour line is a line on a map, and on any one contour line all places are the same height above sea level; or, if the lines are drawn within an area of water, then all places on any one contour line will be the same depth. Where a map is coloured to show different heights, the line dividing any two colours is a contour line.

Suppose a surveyor with his plane table, sight rule and clinometer had fixed the heights in metres of a number of positions on his map as shown in Fig. 55

Then he might draw in the contour lines as the figure for heights of 100, 150 and 200 metres at 50 metre intervals.

(Answers to questions are at the end of the chapter. Don't look at them till you have given your own.)

1. Suppose you were standing at the position marked *X*, at about what height above sea level would you be ?

2. What information is left out in Fig. 55 that should be given on every map or plan ?

You should be able to recognise quickly from contour lines the difference between steep and gentle slopes and between a valley and a spur (the sort of nose sticking out from a ridge

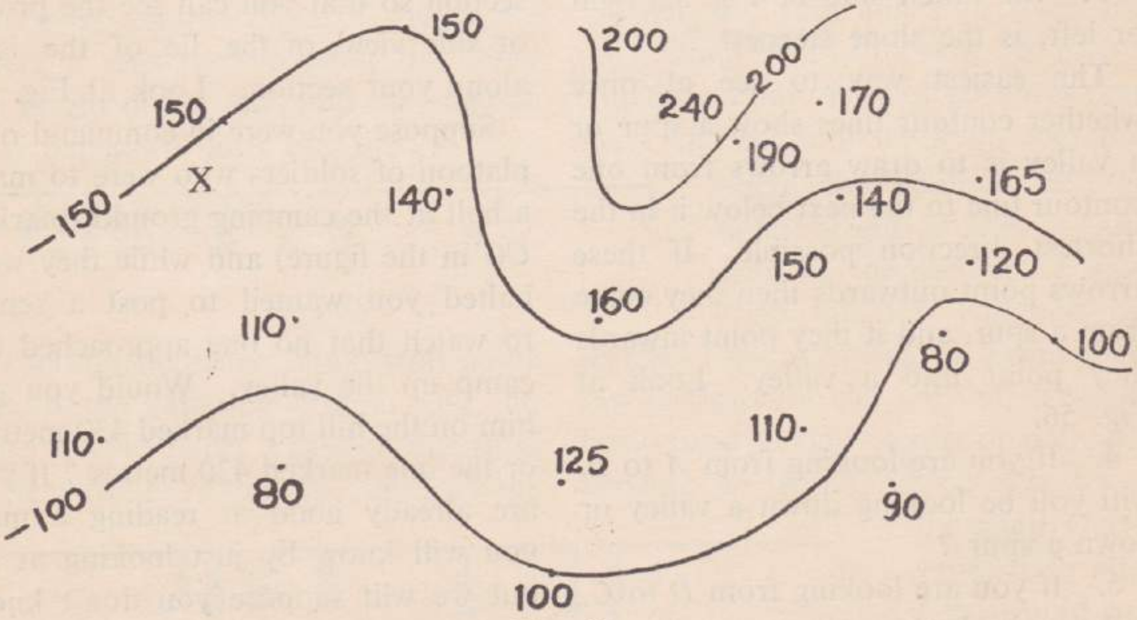


Fig. 55

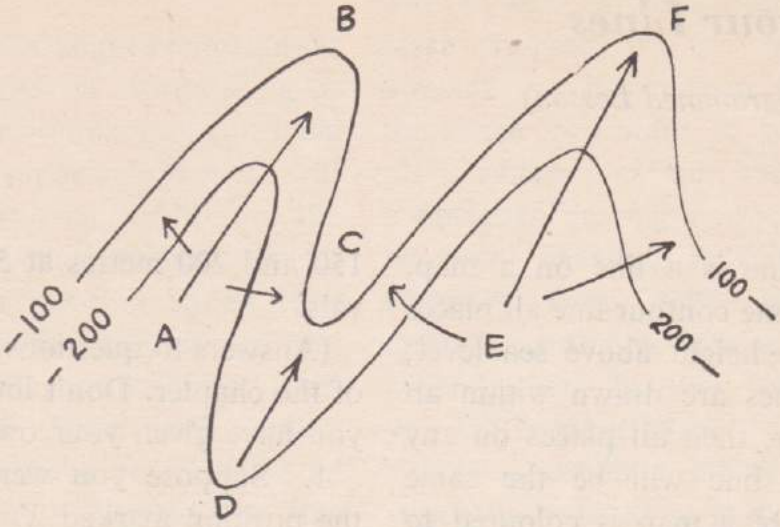


Fig. 56

or range of mountains between two valleys or re-entrants).

Where contour lines are close together the slope is steeper than where they are wide apart, because the rise in height takes place in a shorter distance.

3. On which side of Fig. 55, right or left, is the slope steepest ?

The easiest way to see at once whether contour lines show a spur or a valley is to draw arrows from one contour line to the next below it in the shortest direction possible. If these arrows point outwards then they come from a spur, and if they point inwards they point into a valley. Look at Fig. 56.

4. If you are looking from *A* to *B*, will you be looking down a valley or down a spur ?

5. If you are looking from *D* to *C*, will you be looking down a valley or up a spur ?

6. If you are looking from *E* to *F*, will you be looking up a valley or up a spur ?

It is often useful to draw a section across contour lines. This imagines the land cut along the line of the section so that you can see the profile or side view, of the lie of the land along your section. Look at Fig. 57.

Suppose you were in command of a platoon of soldiers who were to make a halt at the camping ground (marked *CG* in the figure) and while they were halted you wanted to post a sentry to watch that no one approached the camp up the valley. Would you put him on the hill top marked 430 metres, or the one marked 420 metres ? If you are already good at reading a map you will know by just looking at it; but we will suppose you don't know and draw sections from each hill top

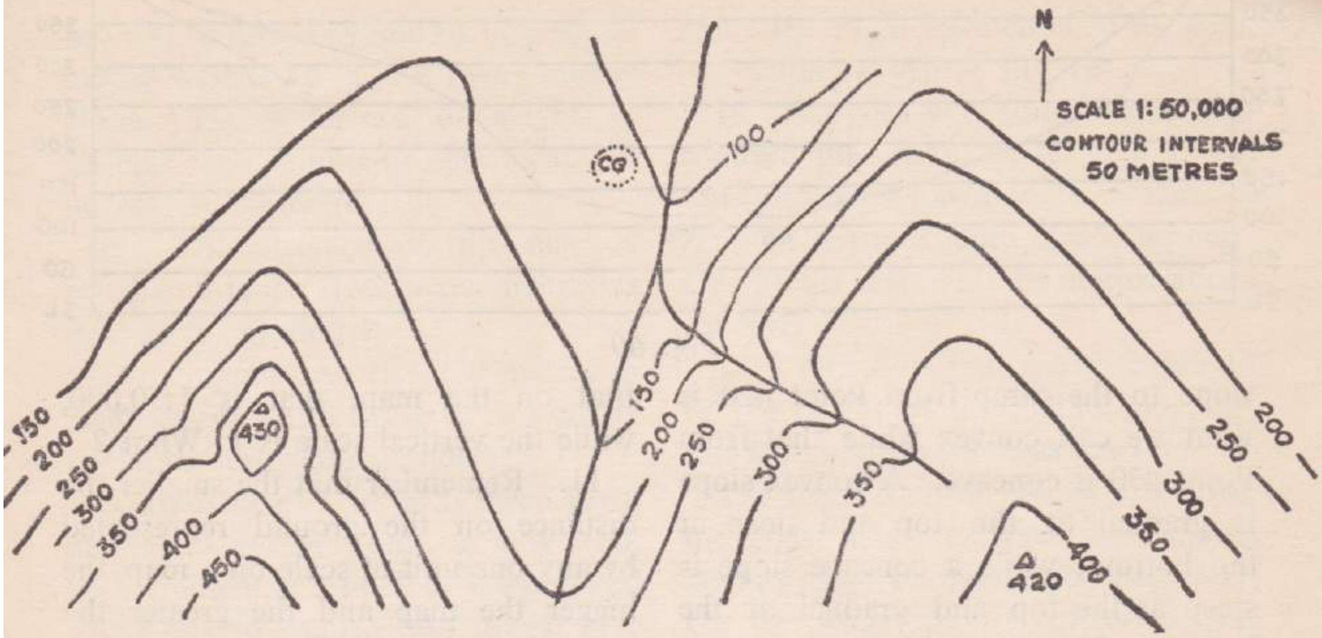


Fig. 57

to the camping ground to see from which the sentry would have the better view.

Take a slip of paper and put its edge from point 430 to the camping ground, and mark on the edge of the paper where it cuts each contour line with the height of the line, and the edge of your paper will look like this:

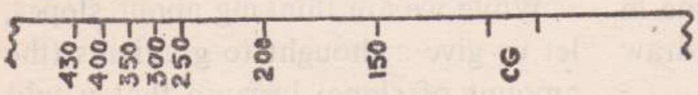


Fig. 58

Then do the same thing from point 420 to the camping ground and the edge of your paper will look like this:

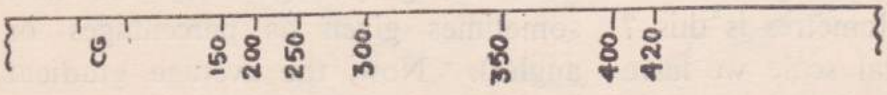


Fig. 59

Next you have to draw your sections for these; if you have any graph paper use it, but if not rule a series of horizontal lines the same distance apart as in Fig. 60 below, where 1 cm=100 metres.

Then take your edges of paper, put them along the line marked 100 metres (for the section will not go lower than that) and make a mark on each line where the contour of the same height crosses it and draw in the sections. I have done this for you and the sections look as in Fig. 60. From these two sections you can see that it would be no good putting a sentry on point 420 because he would not be able to see the camp. One on point 430, however, would have a clear view. The

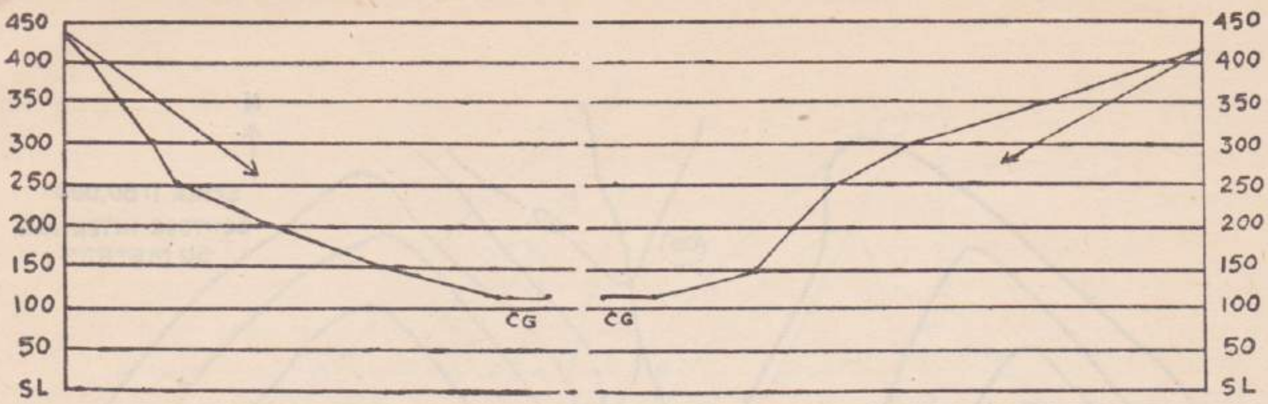


Fig. 60

slope to the camp from Point 420 is what we call convex while that from Point 430 is concave. A convex slope is gradual at the top and steep at the bottom, while a concave slope is steep at the top and gradual at the bottom. You can see down a concave slope, but not far down a convex one.

7. How can you tell that the slope from point 430 to the camping ground is steep at the top and more gradual at the bottom without drawing a section ? (Think of the answer, then see if you have got it right.)

If you want to tell from a map whether one point is visible from another or whether a hill will come in between, the quickest way is to draw a section between the two points.

Now let us consider what is called the vertical exaggeration of the section we have drawn.

8. The scale of the map is 1:50,000 so one centimetre on the map shows how many metres on the ground ?

7. How many kilometres is this ?

10. The horizontal scale we have used for our section is the same as that on the map, that is 1:50,000, while the vertical scale is 1: What ?

11. Remember that the smaller the distance on the ground represented by any one unit of scale on a map, the bigger the map and the greater the scale. For example, if you have two scales in one of which 1 cm = 10 m. and in the other 1 cm=100 m. (*a*) how long a line will you have to draw to the first scale to represent 100 metres and (*b*) how long a line to the second scale?

12. So a scale of 1:1000 is a bigger scale than 1: 100,000. Now think how many times the vertical scale of our section is greater than the horizontal scale ?

While we are thinking about slopes, let us give a thought to gradients (the amount of slope) because that would help you to be able to decide whether you would be able to bicycle up a hill shown on a map, or would have to walk. Gradients are usually given as one of a unit up in so many of the units along (though they are also sometimes given as percentages or angles). Now, the average gradient from the camping ground to point

430 will be found by finding how many metres we rise up in how many metres along. The difference of height, if we take the camping ground as at 110 metres, is 320 metres.

13. The distance on the map is roughly 6 cm. How many metres is that on the ground ?

14. Suppose we rise 320 metres in 3000 metres which is one in how many to the nearest whole number ?

A gradient of 1 in 60 is steep for a railway, a cyclist would usually walk up a gradient of 1 in 20 or steeper, and a car has to change into lowest gear to get up a gradient of 1 in 3 and may boil on the way, if it is as old as mine.

15. Draw a horizontal line 9 cm long and at its end another 1 cm high and measure the angle of the gradient. What is it ?

It may not look it in your drawing, but this is quite a steep slope to push a bicycle up, and if anyone tells you he walked up a mountain slope of 45°, which is 1 in 1, I would not believe him. He might have climbed it, using his hands as well as his feet.

16. Suppose you found on a map contour lines like those in Fig. 61. Can you tell what land form there is between A and B, both of which points are at sea level and 10 metres above sea level ?

17. What do you estimate would be the height of the highest point of this feature above the sea level ?

The basic contour line is, of course, the coast line, the line surrounding land at mean sea level (see Chapter 17, On the Moon and its Effects on the Earth). You know, I hope (and if you don't, look them up in a dictionary) the meaning of words like isthmus and peninsula. You can tell from the contour lines on a map whether, if the sea rose, the tops of a range of mountains would be turned into islands, or whether the ridge between the tops would be turned into an isthmus and a hill top into a peninsula. You will also, as you get practice in map read-

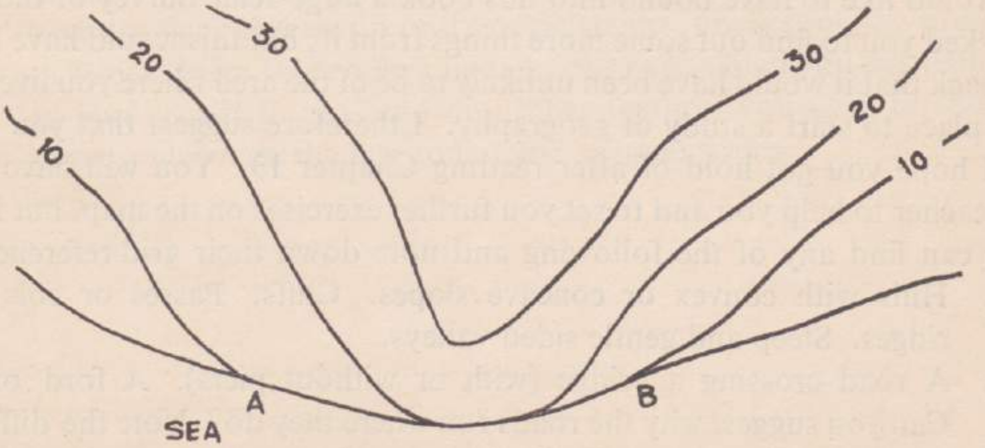


Fig. 61

ing and recognising different arrangements of contour lines, learn to recognise from them many of the different land forms you will study later: dry valleys or re-entrants (possibly a limestone region), hanging valleys and cirques in areas that were once under ice, roads with a gradient too steep for a bullock cart, dip and scarp slopes, cols and passes across mountain and hill ridges and so on.

Answers to questions in chapter 14

1. 140 metres
2. A scale and direction
3. Right
4. Down a spur
5. Down a valley
6. Neither. You would be looking down a spur. Were you caught out? If not, well done!
7. The contour lines are close together at the top and wider apart at the bottom.
8. 500
9. Half a kilometre
10. 1:10,000
11. (*a*) 10 cm. (*b*) 1 cm.
12. 5 times
13. 3000 metres
14. 9
15. 6 degrees
16. A cliff
17. About 24 metres

Something to do after reading chapter 14

I would like to have bound into this book a large-scale Survey of India map and asked you to find out some more things from it; but this would have had the drawback that it would have been unlikely to be of the area where you live, which is the place to start a study of geography. I therefore suggest that you use the map I hope you got hold of after reading Chapter 13. You will have to ask your teacher to help you and to set you further exercises on the map, but first see if you can find any of the following and note down their grid references:

1. Hills with convex or concave slopes. Cliffs. Passes or cols across ridges. Steep and gentle sided valleys.
2. A road crossing a bridge (with or without piers). A ford or ferry. Can you suggest why the roads run where they do? Note the differences between main roads, minor roads, cart tracks and footpaths.

3. A railway running on an embankment, or in a cutting, or through a tunnel. Note the differences between broad and narrow gauge lines. Can you suggest why the lines run where they do?
4. A canal. See if you can find it crossing an aqueduct or going through a siphon. The word aqueduct comes from the Latin words for 'water leading', while siphon comes from the Greek for a 'tube'.
5. A lake with a river flowing into it and forming a delta, or with swamp or reeds at the edge.
6. A river estuary with any of the following marked: low-water line, mud flats, a current that flows up and down river with the tides.
7. Any quarries or mines.
8. If a glacier is shown on your map find its moraines and scree slopes.
9. Find where there are forests, cultivated land and buildings.
   See if you can suggest why the buildings are where they are.
10. Choose somewhere interesting to go to on your bicycle. Using a piece of cotton, measure the distance you would have to go by road, and then compare this with the direct distance.
11. Make copies of the different signs for the following: broad and metre gauge, double and single track railways, a tramway, metalled and unmetalled roads, cart tracks, pony or camel tracks, and footpaths.
12. (An exercise for a group) Make a relief model of your district. Trace onto different sheets of paper each different contour line. Cut a piece of cardboard or three-ply wood (use a fret-saw if one is available) the same size as your plan. Paste the different contour sheets you have traced onto pieces of cardboard or three-ply, and cut round the contour lines. Glue or nail each contour layer onto the piece the size of your plan in the correct order and correct positions. Fill in the intervals between each layer with putty or plasticine, or, best of all, with plaster of Paris. Paint the whole a light colour over which you can paint rivers in blue, roads in red, and any other features you wish to show. On your model state the horizontal and vertical scales.

15. *About Geology and some land forms*

GEOLOGISTS are scientists who study the lithosphere (Greek, *lithos:* a stone or rock) and the Geological Survey of India is the service responsible for, besides much other work, finding valuable minerals in the rocks of India. A rock to a geologist does not mean only hard stone, but also softer stuff like clay and sand, any 'mass of natural substance forming part of the earth's crust'.

A study of geology teaches us of what the earth has been formed, how its surface has changed, and what changes are still going on. Rock formation has been going on since the surface of the earth cooled to a solid crust, and geologists can calculate the age of rocks containing radio-active elements such as uranium. This is because these elements gradually break down into lead at a known rate, and by comparing the amount of lead with the amount of ore remaining, the time that the breakdown has been going on can be worked out. From this and other evidence it has been calculated that the age of the earth is at least 2,000,000,000 years.

How are mountains formed ? Scientists are not yet sure. One theory was that, as the inside of the earth went on cooling and shrinking, it pulled the outside crust towards it by gravity, and the crust crumpled and cracked to form mountains and valleys. Another more acceptable theory known as that of 'Continental Drift' supposes that there was once a single land mass floating on the molten or melted rocks below, and that this has broken up and drifted apart. The west coast of Africa seems to fit into the east of Central and South America. At any rate earthquakes are an evidence that movements of the earth's crust are still going on.

The earliest rocks found to contain fossil (from a Latin word meaning 'dug out') remains of animals are about 500,000,000 years old, and from the study of fossils geologists have learnt much about the history of living things, vegetable and animal, on earth. As rocks get younger more and more complicated forms of life appear, and by studying rocks and fossils we can learn much about the pre-history of a place, of the times it was under the sea or was dry desert, or had tropical swamps or was covered by ice. Fossils of animals that lived in the sea have been found at over 5000 metres up in the Himalayas and these show that parts of the Himalayas have been pushed up from under the sea.

Tennyson wrote:

"There rolls the deep where grew the tree,
Oh, Earth, what changes hast thou seen;
There, where the long street roars, hath been
The silence of the Central Sea.
The hills are shadows, and they flow
From form to form, and nothing stands;
They melt like mist, the solid lands,
Like clouds they shape themselves and go."

Rocks are divided into three main classes: Igneous, Sedimentary and Metamorphic. Sedimentary rocks now cover most of the original crust of the earth, but in many parts molten rocks have welled up from under this sedimentary crust and an upflow still goes on in active volcanoes.

Igneous rocks (from the Latin *ignis:* fire) are crystalline and if the crystals are large they cooled slowly, probably deep down. They occur in irregular masses or veins that have burrowed under pressure into sedimentary rocks. There are two main kinds of igneous rocks: plutonic (from Pluto, the Greek god of the underworld) like granite and quartz with large crystals, and volcanic (Vulcan, the Roman god of fire) with smaller crystals, formed like basalt near the earth's surface by volcanic action.

Sedimentary rocks (from the Latin *sedeo:* I sit down or settle) are mainly made up of bits broken off from earlier rocks and laid down by water or wind in layers or strata (from the Latin for something 'spread') on the floors of shallow seas, lakes, river-beds, or on valleys or plains. Sometimes they are made up of the remains of living things. Sedimentary rocks may be subdivided into three classes: mechanically formed by the forces of erosion (see below) such as clay, sandstone, shale and conglomerate; organically formed from the remains of once living organisms, like limestones from the shells or skeletons of animals mixed with clay or sand, and coal which was once vegetable; and chemically formed by the evaporation of water in which the substances of the rocks have been dissolved, such as rock salt, gypsum, alabaster, and stalagmites and stalactites which you may have seen in caves. The oil, from which we get diesel and petrol, is derived from the remains of living things, and is found trapped under sedimentary rocks. Petrol (from the Greek 'a rock') means rock oil.

Metamorphic rocks (from the Greek for 'change of form') were originally either igneous or sedimentary rocks, but have been changed by great heat or pressure or both. Man makes use of the possibilities of such changes when he turns clay into bricks, or earthenware or china. The rocks of this group yield most of the gold, iron, silver and copper that is found. Marble is limestone that has been changed, slate is changed clay, and quartzite comes from sandstone.

Geologists in India are searching for petrol, and also for underground water supplies. Rocks like chalk and sandstone are porous (from the Greek for 'a passage') or permeable (from Latin meaning 'to go through'), and such rock allows water to soak into it. This water can feed wells. Sometimes, when the water is trapped between layers of impermeable rock such as clay, and a bore is made through the upper layer of impermeable rock, water will come or even spurt up through the bore. The height or level of the water underground is known as the water table. Sometimes the trapped water lies in a depression with the water table higher up the sides of the depression than the bottom of the depression. This is known as an Artesian Basin (from Artois, the province in France where early artesian wells were bored), and in a well bored below the water table, the water will gush up. Artesian wells can also be bored where water in a porous layer of rock slopes downwards between two impermeable layers. If the top layer of impermeable rock is bored below the water table, the water from the permeable rock will come up through the bore without pumping.

During rains the water table rises, and during drought, when there is little or no rain, it falls. This is when the farmer finds his wells going dry. If he is lucky he may be able to deepen them till he comes to water lower down.

A difficult underground supply of water to find is where the water flows in fissures or cracks in impermeable rock like granite. My well is fed like this, and when it goes dry, as it usually does when the water is most wanted in the hot weather, it has been found useless to dig deeper.

A spring is where water comes out of the ground on its own, and may be where water in porous rock flows above impermeable rock till it comes out on the side of a hill, or where it flows in a fissure in impermeable rock to emerge at a lower level.

Geology, as you know, means a talk about the earth, and geologists and geographers have discovered a great deal about all the different land forms —valleys, lakes, cliffs, fiords and other sorts of coast lines, different sorts of islands, and so on, of which the surface of the earth is made up. You will learn more about these as you read more, and here there is time only to touch on some of the land forms you may be familiar with, or have a chance of seeing for yourself.

These land forms are the result of two sorts of action, either movements of the earth's crust from inside which are still going on and can be studied when there are earthquakes or eruptions of a volcano, or moulding by the forces of erosion or denudation, transportation and deposition. You will have realised by now that scientists seem to like using big words, derived from Greek or Latin ! Erosion is from the Latin for 'to gnaw', denudation from the Latin for 'making naked', transportation from the Latin for 'carrying across'', and deposition from the Latin for 'laying down'.

You can often see for yourself the results of movements of the earth's crust where, on a mountain side or the walls of a valley, rock strata are exposed, uncovered by vegetation. The strata will have been laid down as level layers, but are often to be seen folded or faulted (cracked across). There are some strata folded into wonderful and extraordinary patterns in the hills near Manasbal in Kashmir.

Erosion is the way in which the surface of the earth is changed by the wearing away of rocks by water, ice, wind and other agents such as changes in temperature, chemical action and the roots of plants. If you live where there are hard frosts in winter you may have suffered from a burst water pipe. If water turns into ice, the ice takes up more room than the water did, and water frozen into ice in a crack in a rock will gradually split the rock. The salt air beside the sea may cause the chemical erosion of rocks, as you would see if you visited Konarak or the famous temple on the shore at Mahabalipuram. The small amount of acid in rain or running water will gradually eat away limestone, deface buildings and over a much longer period make great caves in limestone areas.

What is eroded in one place will be carried by water, ice or wind and laid down in another. If you live, as I do, in an area where there are dust storms, and fail to close your windows before going to bed and sleep through the storm or are too lazy to get up and do so, you will wake in the morning with everything in your house covered with a layer of dust. When you sweep this up it may not amount to very much, but if you think of this going on for thousands and millions of years, you will be able to realise that wind-blown dust, called loess, probobly blown from the deserts of central Asia, covers huge areas in northern China and is part of the fertile soil that makes the Black Earth of the U.S.S.R. In a desert itself you may have seen sand dunes which are gradually moved in the direction the wind is blowing.

If you live in the hills or have ever been on an expedition into the mountains, you may have slept by a glacier or a great mountain torrent and heard the rocks sliding down the ice of the glacier into pools of water beneath the ice, or boulders bumping down the river bed.

Suppose you live beside a river, you can study many land forms which are the results of all this movement. In its upper course in the hills the river may flow between interlocking spurs. Here erosion is taking place. Observe the silt or mud the water carries and how it cuts into the concave banks. Where there is a waterfall you may be able to see a gorge in the making. Some gorges have been formed when a river flows over a layer of hard rock and then comes to soft rock. The soft rock is worn away faster than the hard rock, and a waterfall is formed. Then the splashing of the river wears away the soft rock under the hard rock, which is left as a lip over which the water falls. Gradually the lip, lacking support, itself falls into the river and gets washed away, and the waterfall works backwards forming the narrow valley with straight sides called a gorge. This is illustrated in Fig. 62.

Lower down, a river where it flows across a plain will be laying down more than it carries away, but it can still eat into its concave banks and will build up the convex banks as the water drops its silt where the current is slow. The river then meanders—a word from a Greek river which winds from side to side—through the plain and may flood it when there is heavy rain in the area from which it collects its waters. This area is known as the catchment area, while the plain liable to flood is called the flood plain. By gradually cutting into the concave bank where the current is fastest, a river in a flood plain may cut across a curve or meander and leave what is called a cut-off or oxbow lake. The *jhils* of the Ganges and other rivers in Bihar and Bengal are often deserted loops of the river. Where a flood plain is narrow enough you may be able to see the ancient banks of the river, known as bluffs at the sides of the flood plain. Fig. 63 illustrates the work of a river in a flood plain.

If you live where a river enters a lake or the sea you will know what a delta is. The name comes from a triangular letter in the Greek

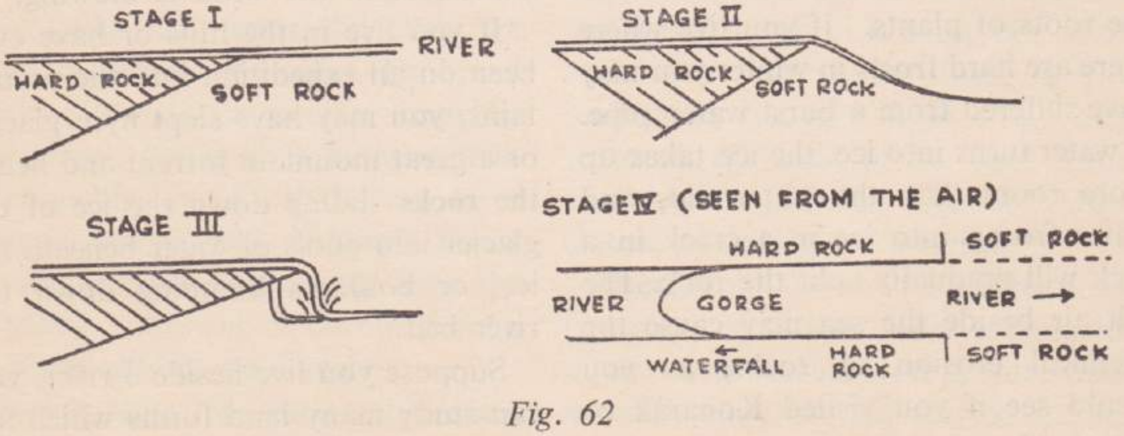


Fig. 62

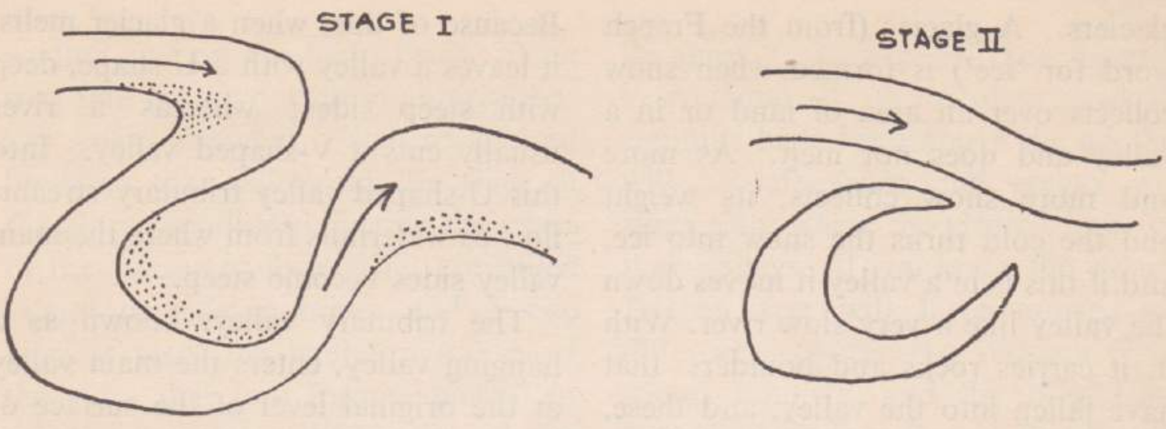


Fig. 63

The arrows indicate the fastest current. The dotted areas are banks of sand and silt dropped where the current is slow.

The river has cut across the narrow neck of land and left its old bed as a jhil *or oxbow lake.*

alphabet.

As soon as a river flows into still water its current is checked and it drops the silt it has been carrying, and this gradually forms a delta or an alluvial fan. They can be easily seen in lakes and valleys in the hills into which water flows.

Now let us suppose you live by a lake. It could have been formed by the collection of water in the crater of an extinct or dead volcano. The word 'crater' comes from the Greek for a 'mixing bowl' and describes the hollow at the top of a volcano that leads down into the earth from where molten rock is forced up to the surface. Extinct is from the Latin for to 'put out'; but you are very unlikely to have seen a crater lake as there is only one lake in India that may possibly be an old crater, at Lonar; and you are unlikely to live by an oxbow lake because of the danger of flooding. Many of India's lakes are artificial, made by man, to store water for irrigation or making electricity. They have probably been made by damming a valley, building a wall across it, or, if a shallow tank, round most of it. Nature has also made lakes by damming valleys. Glaciers may block a valley with the rocks and mud they lay down where they melt. Landslides can hold up a lake in a valley and this can be very dangerous if the barrier breaks; and lakes or lagoons are formed along the coast or sea shore (see below).

If you live in the mountains, or where there have once been glaciers in an age when the earth was much cooler and more of it was covered with ice, you will be able to study the work of glaciers. A glacier (from the French word for 'ice') is formed when snow collects over an area of land or in a valley and does not melt. As more and more snow collects, its weight and the cold turns the snow into ice, and if this is in a valley it moves down the valley like a very slow river. With it, it carries rocks and boulders that have fallen into the valley, and these, frozen into the ice at the bottom, have a great cutting or gnawing power. Because of this, when a glacier melts, it leaves a valley with a U shape, deep with steep sides; whereas a river usually cuts a V-shaped valley. Into this U-shaped valley tributary streams flow as waterfalls from where the main valley sides become steep.

The tributary valley, known as a hanging valley, enters the main valley at the original level of the surface of the main glacier. As a glacier flows over rocks, the boulders it carries will

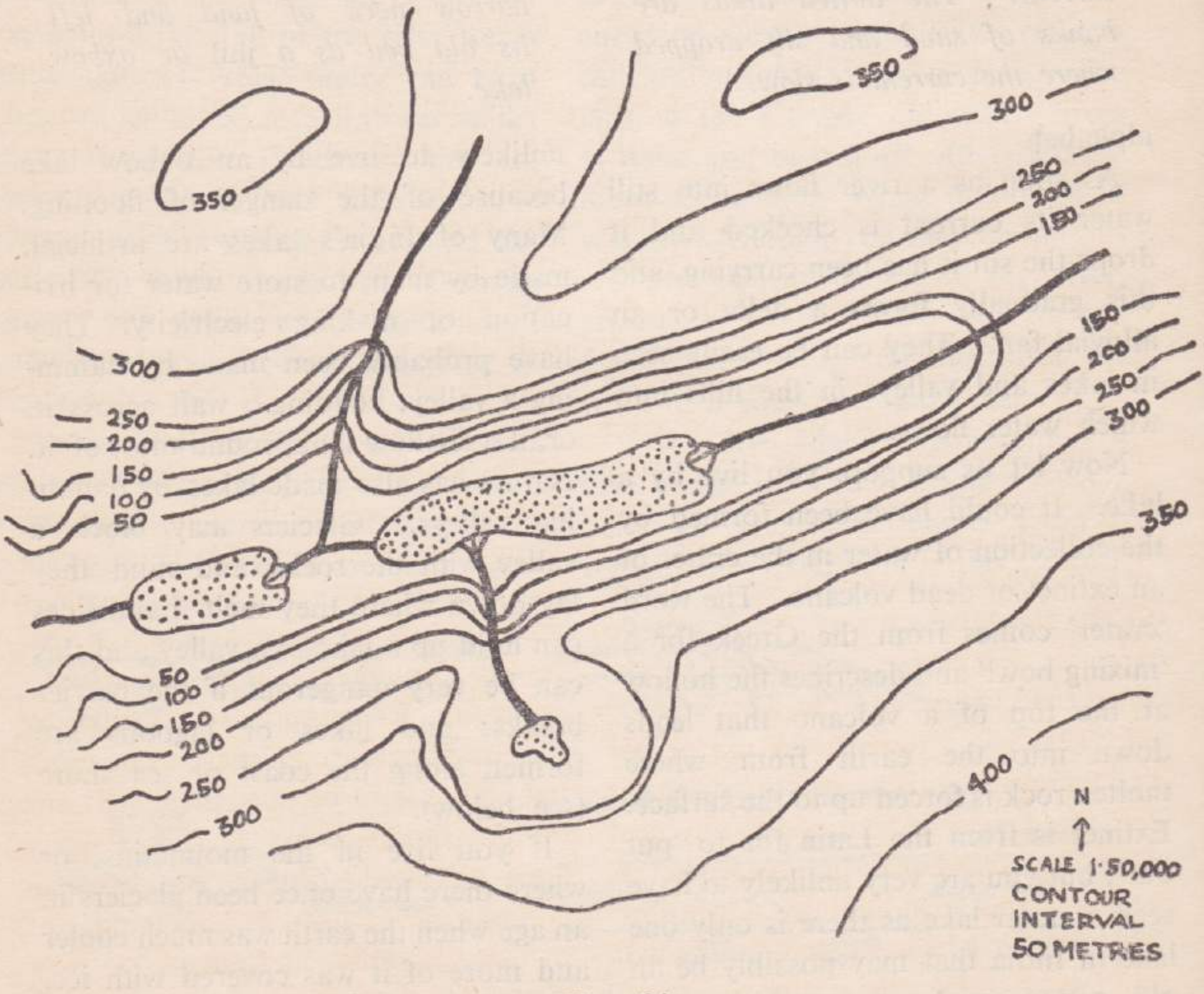


Fig. 64

scratch and cut the rocks below. You may find these yourself in an area that has been glaciated. The rocks and boulders that fall down the sides of the glacier's valley collect on the edges of the glacier to form what are called lateral or side moraines and if two glaciers meet the lateral moraines of the sides that join form a medial or middle moraine. When the glacier ends it lays down its debris to form a terminal or end moraine, which may block the valley when the glacier melts and hold up a lake. Fig. 64 is a contour sketch map of part of an area which was once covered by ice.

Things to notice:(1) The long narrow valley cut by what was the main glacier. (2) The bottom of the valley has been filled by a lake held up by the old terminal moraine at the SW end. (3) Tributary streams come down in hanging valleys. (4) The main river and the tributaries form deltas as they enter the lake. (5) The stream flowing in from the north has cut the lake into two by deposition of silt. (6) To the SE of the lake a stream comes down from an old cirque, a rounded, steep-sided place where snow and ice collected. (7) If you draw a section across the valley it will show you its steep sides and rounded shoulders—typical of an area that has been under glaciers.

The shapes of mountains depend on how they have been formed and eroded and what rocks they are made of. Where hills have been covered by an ice sheet, as in Fig. 64, their tops will be rounded. If, on the other hand, the summits have been above the ice they will be left sharp and craggy with steep sides where the glaciers have cut their valleys. If you know the western Deccan you will have noticed the difference between the Western Ghats round Bombay, and the Nilgiri and Annamalai Hills. Round Bombay the hills are 'square cut and steep sided' composed of horizontal layers of old lava, melted rock that has cooled at or near the surface of the earth. The southern Western Ghats round Ootacamand and Kodaikanal are rounded and undulating like waves on top because they are formed of great masses of ancient crystalline rock. If you know an area of limestone which will dissolve or become liquid in water containing carbon dioxide (the gas used to make 'soda water') it will have steep-sided narrow valleys because the rivers have eroded them quickly, and it may even have dry valleys where the water has disappeared underground into passages and caves dissolved through the limestone rock.

Finally, let us suppose you live by the sea. You are unlikely to be familiar with a fiord because there are none on the Indian coast as it has never been glaciated. But if you lived in Norway or Chile or Scotland, or British Columbia in Canada, or New Zealand, all of which have coastlines to which glaciers did once or still do

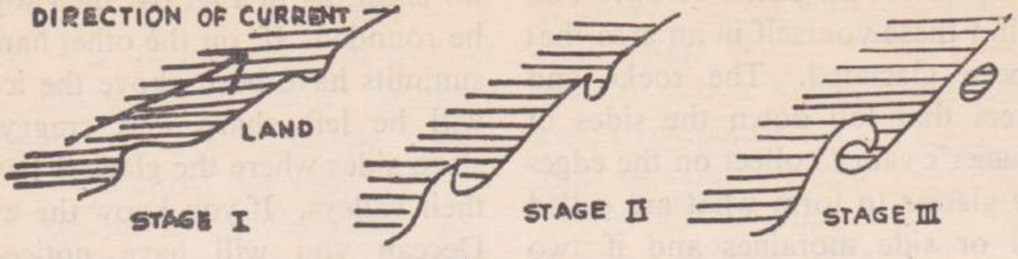


Fig. 65

flow down, you would know what fiords are like. One thing about the sea to remember is that it is not always at the same height along the coasts. Where there are tides (see Chapter 17) it rises and falls every day, and in ages past, owing to movements of the earth's crust, or to more or less melting and freezing of the polar ice caps, the sea level has sometimes been higher and sometimes lower than it is at present. A fiord is where the land has sunk and the sea has risen to fill an old glacier valley, and it will be long and narrow with steep sides. Often it is not as deep near the sea as higher up the fiord, because of the old terminal moraine.

But if you can't see fiords in India there are other interesting sorts of bays and inlets, some of them drowned river valleys or Rias—river valleys into which the rising sea has flowed as the land sank. Others are lagoons —shallow stretches of water cut off or nearly cut off from the sea by strips of land or beach. Where there is a sea current, caused perhaps by tides, along an uneven coast the current is slowed down as it flows past an inlet or on the far side of any land jutting into the sea, and it drops its silt which gradually builds up into a spit which may eventually entirely enclose an area of water.

Fig. 65 shows how this may happen.

If you live on the Malabar coast you will be familiar with these backwaters and lagoons or perhaps you know the Chilka or Pulicat lakes.

Beyond India's coasts are interesting islands. The Andaman and Nicobar Islands are what are called 'continental islands'—rising from a submerged or drowned part of the mainland known as a continental shelf and in both are many inlets, old valleys which have been 'drowned' by the sea. To the east of the Andaman Islands are two islands that were once volcanoes : Barren Island and Narcondam. On the other side of India the Lakshadwip islands are coral islands made up from the skeletons of enormous numbers of tiny little sea creatures which have died where they fixed themselves either to older dead coral or to an already existing island.

In this chapter I have nowhere nearly told you about all the interesting land forms and what goes on to change the appearance of the surface of the earth. I have not even mentioned man who by cutting down forest or exhausting the fertility of the soil may make fertile land into desert. But I hope I have given you some ideas that will encourage you to look at the land forms and features around you.

Something to do after reading chapter 15

1. Make a collection of different rocks and soils and get someone to help you to name them.
2. Try to find some fossils, or go to a museum and see what they look like.
3. As you go about see if you can find examples of any erosion or deposition.
4. Draw a diagram of an Artesian Basin.
5. If you don't already know the meanings of any of the following words, find them from a dictionary (best, if you can get hold of it, would be *A Dictionary of Geography*—a Penguin Reference Book), and make sketches or plans of them.

   Atoll
   Block Mountain
   Cape
   Col
   Continental Shelf
   Estuary
   Folded Mountain
   Gorge
   Gulf
   Island
   Isthmus
   Lava
   Oasis
   Peninsula
   Plateau
   Rift Valley
   Strait

   Draw figures or sketch maps illustrating as many of these as you can.

16. About the Sea and Oceans

A little over 70% or nearly three quarters of the surface of the earth is is sea or ocean. This water is salt water with, on average, 35 parts of salt in 1000 parts of water, though the amount of salt in solution varies. In equatorial regions, where there is heavy convectional rainfall, the water is less salt. Where the dry Trade Winds blow they cause evaporation, and the sea is saltier. In the wet Westerly wind belts the salinity again becomes less; and in the polar regions, where there is little evaporation because it is so cold, less still.

Where rivers flow into a sea they reduce its salinity; for, although river water will contain a little salt in solution, it has much less than the sea. (As I mention the name of a sea or river, find it in your atlas.) For this reason the sea water in the Gulf of Guinea and southwards, with the Niger and Congo rivers flowing into it, has a salinity of only about 30°/₀₀—%=per cent, °/₀₀=per thousand. The Baltic Sea, with many rivers flowing into it, with heavy rain and snow, and little evaporation because of the cold, has a salinity of only 12 °/₀₀ or less. The Black Sea and the Sea of Azov (find the four great rivers beginning with D that flow into them) also have a low salinity of about 17°/₀₀.

Inland seas and lakes, with no river flowing out of them, have, over the ages, collected all the salt brought to them by the in-flowing rivers and may be very salt. The Dead Sea has a salinity of about 250°/₀₀ The Red Sea, almost shut off from the ocean, with no great rivers flowing into it, and with low rainfall and rapid evaporation from the heat, has a salinity of over 40°/₀₀. The Mediterranean, also nearly enclosed by land, has a salinity of about 37°/₀₀.

The salt dissolved in the oceans is largely (about 75 %) the salt we eat with our food, sodium chloride. The remaining 25% are the salts of other minerals.

If you don't already know where they are, find the great oceans in your atlas: the Pacific, the Atlantic, the Indian, the Arctic and the Southern Ocean. The beds of these oceans are sometimes classified into four parts: the Continental Shelf, the Continental Slope, the Ocean Floor or Deep Sea Plain, and the Deeps. The Continental Shelf is where the water around the continents is shallow, not more than about 100 fathoms or 183 metres. Where the land is lowland, the continental shelf beyond it may stretch for

1500 kilometres or more, sloping down very gradually. Where the land is mountainous, the Continental Shelf may be narrow with a quick drop to deep water.

The Continental Slope is where the shelf slopes steeply down to the ocean depths, and the Ocean Floor or Deep Sea Plain lies at depths of between 4000 and 4500 metres. This, like the land, has its plateaux, ridges and valleys.

The Deeps are steep-sided valleys in the deep sea plain, and lie mostly around the edges of the continents and generally where there are active volcanoes and earthquakes. The deepest trench or valley yet measured is in the Pacific, east of Mindanao in the Philippine Islands, where a depth of nearly 12,000 metres has been recorded—a good deal deeper below sea level than Mount Everest rises above it.

Islands like Sri Lanka, rising from the continental shelf, are known, as explained in chapter 15, as continental islands; those rising from the deep sea are called oceanic islands. Some islands are volcanic or coral islands.

The oceans are a reservoir of heat, and their surface temperature is usually a few degrees higher than that of the air above, though their temperature decreases with depth. As ice is lighter than water it floats on the water. If it were heavier the colder seas might freeze from the bottom upwards, and the ice never melt, or melt very slowly. We can tell from fossil remains that there have been times when there was more land and less water than today, and in these times it was very cold—they were ice ages. If the area of the oceans was to become less, the climate suitable for man would change, so for us it is a good thing that so much of the earth's surface is water. Man has yet to learn to farm the seas efficiently, especially the continental shelves where plankton (from the Greek meaning 'wandering'), tiny floating and drifting forms of plant and animal life, abounds and is the food for most of the fish which man catches.

The seas and oceans are in constant movement. The sun and moon attract their waters by gravity to cause the tides (see chapter 17); their waters are evaporated to form clouds and rain, and added to by rain and rivers; at times some of their waters is turned into ice; volcanic eruptions may cause great waves to travel hundreds of miles; differences of temperature cause convection currents as in the atmosphere (see chapter 7); differences of salinity cause a movement of less salt water into the Mediterranean at the surface and more salt water out to the Atlantic through the Strait of Gibraltar, and through other straits where there are big differences between the salinity of the seas on either side of the strait. The most important movements of the seas are caused by the winds. These not only cause the waves that you can see on any tank or lake when it blows hard, but also cause currents in the ocean (refer to the exercise after chapter 7). Like the winds (see figures 39 and 40), the ocean currents, between the equatorial and temperate regions, are deflected by the earth's rotation, the Kuro Siwo and the Gulf Stream flowing clockwise, while similar currents in the southern oceans flow anti-clockwise. You will remember how important these currents are in their effect on the climate of the lands into which winds from them blow.

Something to do after reading Chapter 16

The extracts below are from the Log Book (a sort of diary kept by all ships) of the m.v. "Mahout" from the day she sailed from the Thames Estuary to the day she finished unloading cargo in the Seychelle Islands. Read these extracts and the information given about them and then try to answer the questions that follow.

Information on entries in the ship's log book

(*a*) Distances are stated in nautical miles (see Ch. 13), and speed in knots (sea miles an hour). The speed entered at noon is the average speed for the last 24 hours or hours of sailing.

(*b*) Directions are true bearings. The course is that at noon, unless marked Var, and may be taken to be that of the last 24 hours. Changes of course when entering or leaving harbour have been omitted.

(*c*) Temperatures are in degrees Centigrade, and Pressures in millibars, both for noon each day, unless otherwise given in 'Remarks'.

(*d*) Wind directions are also those at noon, unless otherwise given in 'Remarks'. Forces are according to the Beaufort Scale.

(*e*) Noon positions, given in degrees and minutes, are from observations of the sun. Where the sun was not visible they are marked DR (Dead Reckoning: a position worked out from estimated speed and course).

(*f*) The ship's clocks, off the Thames Estuary, were at British Summer Time (GTM+1 hour). Once she was well at sea the ship observed very roughly Sun Time (noon when the sun crosses the meridian). The time, kept from 0000 to 2400, is entered in the Log Book as GMT+.., GMT, or GMT−..

(*g*) Under 'Remarks' are entered some of those from the Log Book that give some idea of life at sea.

Questions based on the EXTRACTS from the SHIP'S LOG BOOK (See pp. 104, 105)

(These are followed by suggested answers which should be looked at only after you have tried to answer the question yourself.)

1. Plot the daily noon position of the m.v. "Mahout" on a map or chart showing the seas round Africa, and draw in her course.
2. From July 29th to August 4th the temperature tends to rise. Why?
3. From August 4th to the 15th the temperature drops. Why?
4. From August 16th onwards the temperature tends to rise again. Why?
5. Between which latitudes are the SE Trade Winds blowing steadily?
6. Can you explain why there is not a similar belt where the NE Trades blow steadily?
7. Can you account for the low pressure on August 4th & 5th?
8. At midnight between July 29th and 30th the ship's clocks were retarded 30 minutes, which made them GMT+$\frac{1}{2}$ an hour. Why was it not GMT-$\frac{1}{2}$ an hour?
9. Roughly at what longitude was the ship when the clocks were retarded $\frac{1}{2}$ an hour at midnight between July 30th and 31st? (Find the mean of the noon longitudes on the two days).
10. At midnight between August 9th and 10th the clocks were next altered by advancing them $\frac{1}{2}$ an hour. At what longitude did this happen?
11. What was the difference in longitude between the answers to questions 9 and 10: that is between the longitudes that made a difference of $\frac{1}{2}$ an hour in the ship's times?
12. How many degrees of longitude make a difference of one hour in time? State the equation from which this can be calculated.
13. At noon on August 9th the ship had covered 343 miles at 14.29 knots. By noon the next day she had covered 338 miles at 14.38 knots. Account for the fact that, although sailing faster, she had covered a shorter distance.
14. From July 31st to August 2nd the ship was sailing at a higher than average speed of 15.58 knots. What ocean current was helping her along?
15. From August 12th to 14th she averaged only about 13.35 knots. What ocean current was holding her back?
16. Can you suggest any other reason or reasons why she did not make better speed from August 12th to 14th?
17. On August 19th the ship's speed was only 12.85 knots. What ocean current was holding her back?

18. If you noticed that on August 16th the ship was making over 15 knots this might have surprised you. By what current might you have expected the ship to be held back? (The reason she was not held back you would not know, and it is given in the answer.)
19. What is the name of the most southerly tip of South Africa off which the ship altered course to a north-easterly direction?
20. At the Tongue Anchorage the ship used the port anchor, while at Mahe the starboard anchor was used. The reason for this was that, should there have been a cyclonic storm, the ship had to be anchored so as to swing round the anchor without the anchor cable fouling the bows. In what circular directions do cyclonic storms blow in the northern and southern hemispheres?
21. Give the full meanings of the following abbreviations as used in the ship's log book: F.F. equipment; L.S.A.; F. & A.; A/C; S.B.E.

Answers

1. Have you gone aground?
2. Because the ship is sailing southwards into lower latitudes.
3. Because the ship, though still sailing south, is moving south of the sun and away from the latitudes of maximum insolation.
4. Because the ship is moving northwards towards the latitudes of maximum insolation.
5. 07S and 28S.
6. In similar northern latitudes the Atlantic Ocean is much narrower and the effects of the heating of the land masses interfere with the regular or planetary winds. Also, the alterations of temperature and pressure caused by the Gulf Stream circulation affect the regular wind and pressure belts.
7. This was caused by a local disturbance shown by the force 6 winds from the north on August 4th.
8. Because, at Tongue Anchorage, the ship's clocks were at British Summer Time, one hour ahead of GMT.
9. 08.58W.
10. 01.54W.
11. 07.04 degrees.
12. 15 degrees. The earth rotates 360 degrees in 24 hours, therefore 1 hour= 360/24 degrees.
13. At midnight between August 9th and 10th clocks had been advanced ½ an hour, so the ship had only sailed 23½ hours between noon on the 9th and

noon on the 10th.

14. The Canaries Current.
15. The Benguela Current.
16. Adverse winds. Pitching heavily slows down a ship.
17. The Mozambique Current.
18. The Agulhas Current. In fact the ship sailed very close to the land which not only avoided the adverse current, but took advantage of the counter current it set up close to the shore.
19. Cape Agulhas.
20. Anti-clockwise in the northern hemisphere and clockwise in the southern.
21. Fire fighting equipment; Life Saving Apparatus; Fore and Aft; Alter course; Slow both engines.

17. *A little about the Moon*

You may wonder what the moon has to do with the geography of the earth. It is the main cause of the tides in the sea. By the force of gravity it pulls the waters of the oceans towards it. The sun also does this, but being so far away its pull affects the waters less. There are other factors, such as centrifugal force, besides the pull of the moon and sun, involved in explaining tides, but these I must leave till you understand much more about the laws of Physics. You have, however, probably seen what happens to a string or wire pulled very tight. If you pluck it with your finger the string oscillates, or continues to vibrate to and fro. This is one way of making music with a stringed instrument. Now, the waters of the earth do much the same thing as they heap up and sink down as a result of the gravity of moon and sun. In general it is true to say that when sun, earth and moon are roughly in one line the pull of gravity on the waters of the ocean is greatest, and when sun, earth and moon make roughly a right angle, then the pull is least. The moon revolves round the earth roughly once every 29½ days, so roughly once a month the relative positions of the three bodies will be as in Fig. 66 with the sun away to the right.

At positions *B* and *D* the earth, moon and sun are in one line, the pull will be greatest and there will be big or 'spring tides.' At positions *A* and *C* the moon, earth and sun are at right angles, the pull will be in different directions and there will be small or 'neap' tides. At spring tides the sea rises highest and falls lowest; at neap tides the rise and fall is less, and for reasons I will not explain now there are usually two high and two low tides a day.

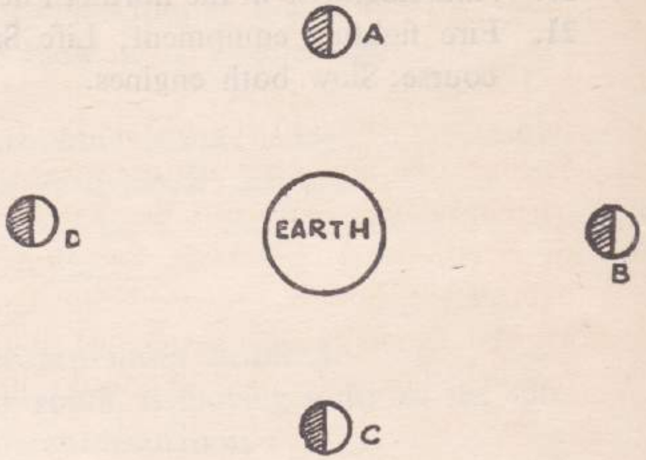


Fig. 66

Where the rise and fall of a tide is along a coast in the open ocean the tide rises and falls much less than where, on a continental shelf, the shore shelves gently and the sea is shallow. Here the lower waters of each rising tide are held up by the shallow sea bed and the waters above rise higher up and the rise and fall of the tides is greater. Sometimes the waters of a high tide flowing into the mouth of a river get held up by the river current and pile up across the river till the crest of the tidal wave falls and rushes up the river as what is known as a tidal bore. You have perhaps heard of or seen this happening in the Hooghly.

Tides are important, both because they enable ships to get into harbours at high tide and because they set up currents which can keep the mouths of rivers clean of silt, or they may deposit silt, and this affects shipping, as well as changing a coast line and making lagoons, as described in chapter 15.

Perhaps you have wondered why there are not eclipses (from the Greek meaning 'fail to appear') of the sun or moon when there are spring tides. Of course, in position *D* the moon appears to be in the shadow of the earth and you might expect a lunar eclipse, but only occasionally will it be in a direct line and usually you will see the full side towards the sun lit up and it will be full moon. In position *B* the dark side of the moon will be towards the earth and it will be 'new' moon. If the moon comes exactly in line with the earth and sun there will be a solar eclipse. In positions *A* and *C* you can see only half the lighted side of the moon from the earth.

Something to do after reading chapter 17

If you can stay beside a beach, notice each day the high and low water marks of the tides. At the times of full and new moon they will be wider apart, higher up and lower down the beach than they are at half-moon.

18. What's more to do

DEAR Lakshmi, Rudra, Shankar—or whatever your name may be—, I have tried to describe the world as it is, though I have not said much about where different minerals are found as that is a very complicated business, and I have not tried to describe all the things that man has done and is doing to the world; where he grows different crops—rice, wheat, tea, rubber, cotton, and so on; or rears different animals —cattle, buffaloes, sheep, poultry and so on; or builds his villages, towns, cities, ports and airports; or the main trade and travel routes by road, train, ship or air; or how the geography of the world has controlled much of the history of mankind. All these you will find out about if you make a study of Human and Regional Geography. But I hope I have helped you to some understanding of why some things are as they are in our world. Some people think that some of the subjects I have asked you to think about are difficult. If you found them so, I hope you have tackled them and defeated the difficulties. Most things worth doing involve patient and hard work. Before you can enjoy the flowers of a lovely garden you have to dig the soil, and a farmer puts in a lot of hard work to produce a crop. So do not think you can become a scholar or start to understand life without this hard work.

Our lives should be a search for Truth which is sometimes harder to discover than a garden is to dig or a field to plough. One day you may perhaps read some of the essays of Francis Bacon (1561-1626). One on Truth begins "'What is truth ?' said jesting Pilate and would not stay for an answer." Bacon in trying to give an answer writes among other things of 'the difficulty and labour which men take in finding out the truth., Some of these difficulties I have hinted at in this little book. If you want to find truth then be observant, ask yourself 'Why this and Why that ?' and do not be afraid of thinking hard. Exercise your brains if you want to develop them, and all good luck to you.

Here are some suggestions for what you may find out about the district where you live, before you start, or while you are making, a detailed study of Regional Geography. Use a Survey of India map of your district.

1. Consider the air, rail and road communications of your district. Can you decide why any town is situated where it is ? If a railway or road changes its direction, why

does it do so ?

2. If you live near a port, draw a sketch map to show the harbour and the main shipping routes converging there. Find out what you can about its chief articles of trade.
3. If you live in a great city, find out about its history and make a list of the historical and geographical conditions that have led to its growth.
4. If you live near a railway junction, draw a sketch map showing where the lines that meet there go to and make a list of the important products that they carry.
5. If there is a mine in your district, or you can visit one, learn what you can of the mineral mined, how it is treated and what it is used for.
6. Study any factory in your district. Find out from where it gets its raw materials, how it manufactures them, and where it sells its products.
7. If you have electricity in your area, find out where it comes from, how it is brought, and how it is generated.
8. What crops are grown in your district? When are they sown and harvested, and how are they treated after harvest ?
9. Where does your water supply come from? If you have a well, through what sort of rock is it dug, and how does the water table alter ? If there is a lake or tank in your district, study the catchment area—the area from which it collects its water. If you are served by a canal, describe its source of supply, where it eventually ends, and whether it is perennial or not and why.
10. Study any forest in your district. What trees are grown, and what is their wood used for ? How is the wood moved from the forest ? Why is it important that forests should be preserved ?
11. If you live in a district where plantation crops (tea, rubber, coffee, etc.) are grown, study their cultivation, harvesting and disposal. Find out why they are usually owned by companies rather than individuals. Where do the labourers come from, and how do they live ?
12. Is there any Transhumance, the seasonal movement of people, into and from your district ? For example, herdsmen may move from one area to another with their flocks at different seasons; or workmen may come at special times of the year for special jobs. Where do they come from, and how do they live ?
13. If you live in a place which is a centre of pilgrimage, ask some of the pilgrims where they come from and how they got to the centre. What differences can you notice in people from different

parts of India ?

14. If you live in or near the mountains, describe the differences in the life, houses, food and clothes of the people there from those who live in the plains.
15. If you live near a river, follow its course as far as you can and describe why it takes that course. Describe anything its waters are used for.
16. What domestic and wild animals live in your district ? What do they feed on, and what use does man make of their produce ?
17. If there is a dam in your district make a sketch map of its catchment area and the sources of the water in the lake it holds up.
18. If there is a fort in year district find out all you can about its history, why it was built where it is, and what it protects.

Index

Where it is advisable to refer to a whole chapter or large part of it, references to the chapter are in bold numerals. An asterisk (*) suggests that if you do not know the word, you should look it up in a dictionary.

Adriatic Sea 56
age of Earth 90
Alaska Current 42
alcohol thermometer 52
Alexandria 5-7
algebra 7
alluvial fan 95
a.m. 27
Andaman Islands 98
anemometer 53
Annamalai 3, 97
Antarctic Circle **5**
anti-cyclones 56
Arabs 4, 7
Arctic Circle **5**
Arctic Ocean 100
artesian well 92
Aswan 5-7
Atacama Desert 68
Atlantic Ocean 100
atlas 12
atmosphere 34
atmospheric pressure, see pressure
atoll*, 99
axis **3** and **5**
azimuthal map 73
Azov, Sea of 100
Babar 22
back bearing 82
Baltic Sea 100
Bangalore 3
bar 52
barometer 52
Barren Island 98
base line 74
bay 98
bearings: true, compass and grid **13**
bench mark 79
Benguela Current 42
biology 1
Black Sea 100
block mountain *99
bluffs 94
Bombay 62, 65, 97
Bonne **11**
bora 56
bore, see under tides
Brazil Current 42
breeze 54

Calcutta 3
Californian Current 42
Californian Desert 68
Canaries Current 42
Cancer, Tropic of **5**
cape*, 99
Capricorn, Tropic of **5**
carbon dioxide 97
cardinal points 17
cartographer 16
catchment area 94
Chilka Lake 98
China Type climate 41
chinook 56
chronometer 47
circumference 4
cirque 97
cliff 87-88
climate 51, **10**
clinometer 75
coal 91
col*, 99
compass 76
concave 52
concave banks 94
concave slopes 86
condensation of water vapour 53, 55
conical projection **11**
coniferous forest 63,66,67
Continental Drift 90
continental island 98
continental shelf 98, 100, 101
continental slope 100-101
contour lines **12, 14**
convection currents 64
convectional rain 38, 67

convex 52
convex banks 94
convex slopes 86
Copernicus 22
coral islands 98
corresponding angles 4,
cotton 62
crater 98
currents, see under ocean
cut-off 94
cyclonic depressions 39-40, 55-56, 68-69
cylindrical projection **11**

date line **6**
day and night **5**
Dead Sea 100
deciduous trees 63
degrees in a circle 5
Delhi 65
delta 94-5
denudation **15**
deposition **15**
depressions, see under cyclonic depressions
deserts **10**
dew 55
direction **4**
dividers 14-15
doldrums 34
drought 92
dry bulb thermometer **9**

earthquake 90
East Australian Current 42
eclipse 107
ecliptic, see under plane of the
ellipse 22
equation 7
equator **3, 5**
Equatorial Counter-Current 42
equatorial forest **10**
equinox **5**
Eratosthenes **2**
erosion **15**
estuary*, 99
evaporation 53
Everest 74, and see also under Mount Everest

fiord 97-98
flood plain 94
föhn 56
folded mountains,* 99
fossils **15**, 101

gale 54
Galileo 4
Gall **11**
Gauhati 3
geography 1
geology 2, **15**
Geological Survey of India 90
geometry 2
geos 1
Gifford, Colonel 3
glaciers **15**
gorge*, 94, 99
gradient 86-87
graphs of weather **10**
Great Circles 78
Greenwich 10
Greenwich Mean Time (G.M.T.) **6**
grid **11**
gulf*, 99
Gulf of Guinea 100
Gulf Stream 42

hail 55
hanging valley 96-97
Hardwar 3
harmattan 57
height and temperature 34, 54
hemisphere **3**
hoar frost 55
homolographic map 73
horizon 24
Horse Latitudes **7**
Human Geography **18**
humidity **9**, 62
hurricane 54

ice 53, 96, 101
ice ages 101
ice cap **10**
igneous rocks **15**
Indian Meteorological Service 51
Indian Ocean 100
Indian Standard Time (I.S.T.) **6**
International Date Line **6**
island *, 99
isobars **9**
isohyets **9**
isotherms **9**, 64
isthmus*, 99

jhils 94-95

Kalahari Desert 68
Kanpur 2
Kepler 22
Kishengarh 3
knot 79, 102
Kodaikanal 97
Konarak 93
Kuro Siwo 42

Labrador Current 42
lagoon **15**
lakes **15**
Lakshadwip Islands 98
Lambton 74
land and sea breezes 55
land forms **15**
latitude **3**, 24, **8**
lava *, 99
lead 90
limestone **15**
lithosphere 90
local time 48
loess 93
log book 102-105
longitude **3, 5, 8**
Malabar 3, 98
Mahabalipuram 93
Manasbal 93
map making **13**
map projections 11, **11**
map reading **12**
map signs **13**
mariner's compass 17
mausim 51
meander **15**, 94
measurement 14
Mediterranean Climate 41; **9, 10**
Mediterranean Sea 56,101
Mercator 12, **11**
mercury thermometer **9**
meridians of longitude, see longitude
metamorphic rocks **15**
Meteorology 51
metre 79-80
midnight 22, **6**
mile 79
millibar **9**
Mindanas Deep 101
minutes of angle and time 11, **8**
mistral 57
Moguls 53
Mollweide **11**
monsoon climate 51, **10**
moon **17**
moraine **15**
mountains 63
Mount Everest 51

Narcondam Island 98
natural vegetation, see under vegetation
nautical mile 79-102
neap tides 106
Nicobar Islands 98
Nilgiris 97
noon 22, **6**
North Equatorial Current 41-42

oceans **16**
ocean currents 41-42, 102
oasis *, 99
Ootacamund 97
oceanic island *, 99
orrery 26
orthomorphic map 73
ox-bow lake 94-95

Pacific Ocean 100
pampas 63
parallel lines 4,
parallels of latitude, see latitude
penicillin 22
peninsula *, 99
permeable rock 92
Peru Current 42
petrol 91, 92
photography 1
photosynthesis 1
plane 22
plane projection **11**
plane table **12**
plane of the ecliptic **5**
planet 21
plankton 101
plateau *, 99
p.m. 27
plutonic rocks 91
points of the compass 17
Pole Star 43-44
poles **3**
Pondicherry 2
Poona 3, 65
porous rock 92
port 17
prairies 63
prefix 2
pressure of the atmosphere **9**
proportion 14

Protractor 6
Pulicat Lake 98

Ra voyages, the 44
radius 4
rainfall, convectional 38, **9**
  cyclonic 39, **9**
  relief 38, **9**
rain gauge 52
rain shadow 39, 65
range of temperature 58
ratio 14
Red Sea 100
Regional Geography **18**
representative fraction 14
revolution of the earth 5, **5**
ria 98
rice 62
rift valley *, 99
right angle 4
rotation of the Earth **5**,102

Sahara Desert 98
salinity of sea 100, 101
sand dunes 93
satellite, 21, 51
saturated air 53
savanna 63
scale 6, **4**
seasons **5**
seconds of angle and time 11, **8**
sedimentary rocks **15**
Seychelle Islands 102
shadow circle 23
sight rule 75
sirocco 57
snow 55
sodium chloride 100
solar system 21
solstice **5**
South Equatorial Current 42
Southern Oceans 42
sphere **3**
spheroid **3**
spirit level 75
springs 92
spring tides 106
Sri Lanka 101
starboard 17
steppe 63
strait *, 99
strata 91
suffix 2
Sun's distance 5-6, 23
Sun's rays 5-6, **5**
sunrise and sunset **5**
surface tension 52
survey **12**
Survey of India 74, 78

tangent 4
templet 63
temperate forest **10**
temperate grasslands **10**
temperature **9**
temperature range, see under range
Thar Desert 68
textiles 62
thermometers **9**
tides **17**
time **6, 8**
trade winds 49
transportation **15**
triangulation **12**
Trichinopoly 3
tropical forest **10**
tropical grasslands **10**
tropics **5**
tundra **10**
twilight 24
Tycho Brahe 22

universe 21
uranium 90

vegetation, natural **10**
veld 63
vertical exaggeration 97-86
vertically opposite 7
Vizianagram 2
volcanic islands 98
volcanic rocks **15**
volcano 95

water table 92
water vapour 34, **9**
weather **9**
weather chart **9**
weather-cock 53
Western Ghats 97
wet bulb thermometer **9**
wheat 62
wind **9**
wind vane 53
world clock 31

zenith 4-7, 44-45
zenith distance 5-7, 26, 44-45

SOME RECENT BOOKS

1. SOME NEIGHBOURING COUNTRIES

A study of Afghanistan, Nepal, Bangladesh, Burma, Sri Lanka and Malaysia

by

Dr. N. A. Siddiqui
Head of the Department of Geography
Dyal Singh College, New Delhi

and

Mrs Sampuran Jeet
Delhi Public School
New Delhi

This book fully covers the syallabus of Geography paper of the Higher Secondary Examination of the Central Board, Delhi. Up to date facts and figures with numerous maps illustrate the text. Rs. 18.00

Crown 4vo pp. 124 (Paperback) Rs. 10.00

2. PRACTICAL ENGLISH GRAMMAR AND COMPOSITION

by

H. C. Katyal, M.A., B.T.
Vice-Principal
Vallabharam Mehta Public School
New Delhi

M. L. Babbar, M.A., P.G.C.E.
(C.I.E., H'bad)
English Deptt. Modern School
New Delhi

and

S. Natarajan, M.A., B.T.
English Deptt., D. T. E. A. Higher Secondary Schools
New Delhi

The book covers the syllabus in three parts: (i) functional grammar, (ii) correct usage and (iii) composition.

The book is written strictly in accordance with the syllabus of the Secondary School Examination of the Central Board of Secondary Education, Delhi and adequately covers both courses 'A' and 'B' of 10+2 pattern. It fulfils the requirements of students studying both in public schools as well as the other schools irrespective of the medium of instruction.

Crown 8vo pp. 548 Rs. 10.00

3. A TALE OF TWO CITIES

Dramatized by Mina Swaminathan

Charles Dickens' immortal classic, simplified and abridged in a dramatic form by Mina Swaminathan, a renowned educationist, for school students. A swift and thrilling story of the days just before and during the French Revolution has been recreated in the scenes of this play, which students can enact without a lot of paraphernalia.

Crown 8vo pp. 80 Rs. 4.00

MUKUL PRAKASHAN
J-2 Kailash Colony
New Delhi 110048